

EMOTION REGULATION AS A POTENTIAL MECHANISM EXPLAINING THE LINK
BETWEEN CHRONOTYPE AND ALCOHOL USE

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Evening chronotype is strongly associated with greater alcohol use, though mechanisms underlying this association are not well understood. Difficulties with emotion regulation may be involved. Evening chronotypes report less emotional stability and are at increased risk for psychopathology associated with poor emotional control. The current study evaluated chronotype differences in emotion regulation using a standardized laboratory task and evaluated emotion regulation as a potential mechanism linking evening chronotype and alcohol use.

Eighty-one undergraduates from the University of Pittsburgh were studied. Chronotype was assessed using the Composite Scale of Morningness. Alcohol use was reported daily using an online diary and the Alcohol Use Disorder Identification Test (AUDIT). Participants completed an emotion regulation task, within two hours of their habitual wake-time, wherein they attempted to down-regulate negative and up-regulate positive emotions while viewing emotionally-charged images. Self-reported affect, heart rate variability (HF-HRV), and pre-ejection period (PEP) were measured throughout the task.

Thirty-one evening chronotypes were compared to 50 intermediate chronotypes. Evening chronotypes reported significantly greater symptoms of alcohol use disorder ($F = 4.399$, $p = 0.039$). There were no chronotype differences in self-reported affect, HF-HRV, or PEP during the emotion regulation task. Longer sleep duration on non-free days was associated with

increased HF-HRV during negative emotion regulation among intermediate chronotypes. Earlier testing sessions were associated with increased HF-HRV during negative emotion regulation among evening chronotypes. Moderated mediation revealed that emotion regulation did not mediate the association between evening chronotype and alcohol use, irrespective of sleep duration on non-free days or time of testing session.

This study adds to the body of literature by demonstrating that undergraduate evening chronotypes endorse greater symptoms of alcohol use disorder but not greater daily alcohol consumption. Results did not support the role of emotion regulation as a mechanism. Longer sleep duration appears to be protective for intermediate chronotypes in terms of parasympathetic control during the regulation of negative emotions. Time of day effects may indicate that evening chronotypes with earlier wake patterns exhibit better parasympathetic control when regulating negative emotions. Future studies are needed to examine the role of habitual sleep duration and timing in emotion regulation tasks.

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Introduction

The “evening chronotype” is associated with a number of poor health behaviors, not least of which is alcohol consumption. Evening chronotype, or preference for evening hours, has been associated with greater alcohol consumption, binge drinking and symptoms of alcohol dependence (Taylor, under review). Mechanisms explaining the link between evening chronotype and alcohol consumption are not well understood.

Emotion regulation is one potential mechanism linking chronotype and alcohol use. Emotion regulation is highly sensitive to chronic sleep restriction (Gruber & Cassoff, 2014), which is prevalent among evening chronotypes (Kabrita, Hajjar-Muca, & Duffy, 2014; Merikanto, Kronholm, Peltonen, Laatikainen, Lahti, & Partonen, 2012). Extant literature suggests that evening chronotypes report less emotional stability (Ottoni, Antonioli, & Lara, 2012), endorse fewer positive mood states (Biss & Hasher, 2012), and are at higher risk for mood disorders (Antypa, Vogelzangs, Meesters, Schoevers, & Penninx, 2016) relative to morning and intermediate chronotypes, suggesting that evening chronotypes may also demonstrate difficulties with emotion regulation. Emotion regulation has also been shown to be mechanistically related to alcohol use in other populations at high-risk for alcohol use problems (Radomski & Read, 2016; Weiss et al., 2012). Therefore, if emotion regulation is compromised in evening chronotypes, emotion regulation may constitute a mechanism through which evening chronotypes engage in greater alcohol consumption. The current study examined chronotype differences in emotion regulation using a standardized laboratory task and evaluated emotion regulation as a potential mediator of the chronotype-alcohol use association.

Explaining the association between chronotype and alcohol use is particularly relevant for older adolescents and emerging adults, in their late teens and early twenties, who exhibit the highest prevalence of dangerous alcohol consumption (US Department of Health and Human Services, 2013) and, developmentally speaking, are likely to identify as evening chronotypes (Roenneberg et al., 2004). Starting in the pre-teen years and continuing into early adulthood, individuals tend to exhibit an increasingly evening chronotype (Carskadon, Acebo, & Jenni, 2004). While this developmental shift has largely been demonstrated through self-report measures, other research indicates that the shift toward the evening chronotype is biological (Carskadon et al., 1997; Crowley et al., 2014; Crowley, Acebo, & Carskadon, 2012) rather than simply the product of social and/or behavioral development. Therefore, identifying modifiable downstream consequences of the developmental shift toward the evening chronotype may be necessary for disrupting the pernicious chronotype-alcohol use association.

Emotion regulation constitutes a modifiable skill that can be targeted and enhanced through clinical treatment, such as cognitive behavioral therapy (CBT; Berking et al., 2008). If emotion regulation mediates the association between chronotype and alcohol use, clinical interventions to strengthen emotion regulation skills could be used to attenuate alcohol use in evening chronotypes. In addition, if the hypotheses of the current study are confirmed, emotion regulation may be identified as a mechanistic pathway to other health-risk behaviors exhibited by evening chronotypes such as illicit drug use (Prat & Adan, 2011; Fernandez-Mendoza et al., 2010) or unhealthy diet (Patterson, Malone, Lozano, Grandner, & Hanlon, 2016; Kanerva et al., 2012). The current study extends the literature by 1) being the first experimental study to examine emotion regulation in relation to chronotype; 2) being one of the first studies to test a potential mechanism in the chronotype-alcohol use association; and 3) being one of the first

studies to experimentally test both positive and negative emotion regulation in relation to alcohol use. In addition, this study contributes to the scant literature on modifiers of the association between chronotype and alcohol use by testing sex, sleep duration, positive affect, and personality traits as moderators.

Support for the role of emotion regulation in the chronotype-alcohol use association will be provided by first reviewing the literature on alcohol use in evening chronotypes and the association between emotion regulation and alcohol consumption. We then examine the evidence implicating emotion regulation difficulties among evening chronotypes and support for exploratory investigation into several moderating factors: sex, sleep duration on non-free days, positive affect, conscientiousness, extroversion, and neuroticism. We then outline our methodological approach, analytic plan, results, and a discussion of our findings within the context of the broader literature.

Specific Aims

As depicted in the conceptual model shown in Figure 1, the primary purpose of the current study was to test emotion regulation as a potential mechanism linking chronotype and alcohol use. The following specific aims were in service of fulfilling this primary purpose:

Primary Aims:

Aim 1. Replicate previous findings demonstrating an association between chronotype and alcohol use. Based on the extant literature, we hypothesized that evening chronotypes would report greater alcohol use relative to morning chronotypes.

Aim 2. Test the hypothesis that evening chronotypes have poorer emotional regulation relative to morning chronotypes.

Aim 3. Test the hypothesis that emotion regulation statistically accounts for the association between chronotype and alcohol use.

Exploratory Aims:

Aim 4. Evaluate sex as an effect modifier of associations in the conceptual model

Aim 5. Evaluate sleep duration as an effect modifier of associations in the conceptual model

Aim 6. Evaluate positive affect as an effect modifier of associations in the conceptual model

Aim 7. Evaluate the personality traits conscientiousness, extroversion, and neuroticism as effect modifiers of associations in the conceptual model

Background & Significance

Evening Chronotype & Alcohol Consumption

As we have previously reviewed (Taylor et al., under review at Sleep Medicine Reviews), evening chronotype is associated with greater alcohol consumption (Kanerva et al., 2012; Adan, 1994; Prat & Adan, 2011; Watson, Buchwald, & Harden, 2013; Del Rio-Bermudez, Diaz-Piedra, Catena, Buela-Casal, & Di Stasi, 2014; Fernandez-Mendoza et al., 2010; Ishihara et al., 1985; Nakade, Takeuchi, Kurotani, & Harada, 2009; Robinson et al., 2013; Collado-Rodriguez, MacPherson, Kurdziel, Rosenberg, & Lejuez, 2014; Tavernier, Munroe, & Willoughby, 2015; Whittier et al., 2014; Gau et al., 2007; Negri, Dorn, Pabst, & Susman, 2011; Urban, Magyarodi, & Rigo, 2011), binge drinking (Watson et al., 2013), and a greater level of alcohol dependence (Hasler, Sitnick, Shaw, & Forbes, 2013). The literature on chronotype and alcohol use is highly consistent with evening chronotypes endorsing significantly more alcohol consumption relative to morning chronotypes. Out of 28 studies that explicitly examined associations between chronotype and alcohol use, 25 found that eveningness was associated with greater alcohol consumption.

Greater alcohol use among evening chronotypes is concerning given that a majority of adolescents experience a shift toward eveningness, beginning around age 12 (Randler, 2011). Prevalence of the evening chronotype begins to plateau during the late teenage years, followed by a decline in early adulthood; however, many individuals continue to be evening chronotypes throughout their early twenties (Roenneberg et al., 2004). Understanding the association between chronotype and alcohol consumption among those in their late teens and early twenties is particularly important given that this age group lies at the cusp of autonomy, often having access to alcohol but lacking the experience needed to make responsible decisions. Problematic drinking is highest among individuals in their early twenties (US Department of Health and Human Services, 2013) and, within this age group, almost half of all deaths due to unintentional injury or motor-vehicle crashes are alcohol-related (Hingson, Zha, & Weitzman, 2009). Thus, understanding predictors of alcohol use in this demographic is of vital importance from a public health perspective.

Emotion Regulation & Alcohol Consumption

Emotion regulation is a multifaceted construct, composed of both spontaneous and volitional processes. These processes are involved in the generation, appraisal and modification of emotional states. Emotion regulation is often defined in terms of the ability to down-regulate unpleasant mood states (Gross, 2002) or to up-regulate or maintain positive mood states (Hechtman, Raila, Chiao, & Gruber, 2013). Difficulties regulating emotions internally may cause individuals to seek out an external means of regulating emotions, such as alcohol (Aurora & Klanecky, 2016).

Alcohol is used as an external means of both reducing negative emotions and enhancing positive emotions (Beseler, Aharonovich, & Hasin, 2011; Grayson & Nolen-Hoeksema, 2005;

Grekin, Sher, & Krull, 2007; Cooper, Frone, Russell, & Mudar, 1995). Thus, there are two primary pathways through which difficulties with emotion regulation may lead to greater alcohol consumption: a coping pathway and an enhancement pathway. The coping pathway indicates that alcohol can be used as a form of self-medication for regulating unpleasant mood states when individuals lack the necessary skills to self-regulate (Berking, 2011). For instance, negative mood states precipitate substance use, addiction, and relapse (for review: Khantzian, 1997); while, emotion regulation training has been shown to reduce substance use (Azizi, Borjali, & Golzari, 2010). The enhancement pathway indicates that deficits in emotion-regulation skills may cause individuals to use alcohol as a means of increasing the pleasurable value of stimuli or activities (Gilpin & Koob, 2008). Lower sensitivity to reward, as indicated by lower responsivity of the behavioral activation system (BAS) during reward receipt, has prospectively predicted greater frequency of alcohol use two years later (Derefinko et al., 2016). As such, internal abilities to down-regulate negative affective states and up-regulate positive affective states are of great interest within the alcohol use and misuse literature.

Associations between emotion regulation difficulties and greater alcohol use have been replicated numerous times (Radomski & Read, 2016; Aurora & Klanecky, 2016; Klanecky, Woolman, & Becker, 2015; Dvorak et al., 2014). Alcohol may directly influence emotion by enhancing or blunting physiological arousal (Curtin, Lang, Patrick, & Stritzke, 1998). Alcohol may also modulate emotion indirectly by altering attention toward or away from emotion-eliciting stimuli or by altering an individual's appraisal of those stimuli (Curtin et al., 1998). Strengthening emotion regulation skills through psychoeducation programs has also been shown to reduce heavy drinking (Stasiewicz et al., 2013). Therefore, if the ability to regulate positive

and/or negative emotions is compromised in evening chronotypes, it is plausible that emotion regulation may constitute a critical mechanism linking chronotype and alcohol consumption.

Emotion Regulation & Chronotype

Emotion regulation abilities have not been systematically examined across chronotype groups in any peer-reviewed publication. To our knowledge, only one conference presentation has reported measuring emotion regulation in relation to chronotype. Voinescu and Szentagotai (2014) evaluated responses on the Difficulties with Emotion Regulation Scale (DERS; Gratz & Roemer, 2013) in relation to chronotype in a sample of adults (ages 19-63, mean age = 26.5 ± 7.7 years). The investigators found that evening chronotypes had significantly higher scores on the DERS relative to other chronotype groups (Voinescu & Szentagotai, 2014). Measured continuously, chronotype was also negatively correlated with the DERS, indicating that greater morningness was associated with fewer difficulties with emotion regulation.

Related literature suggests that evening chronotypes are more emotionally labile than morning or intermediate chronotypes (Jeong Jeong, Moon, Min Park, Dae Lee, Choi, & Chung, 2015). Evening chronotypes score significantly lower than morning chronotypes on trait measures of emotional stability, emotional control, and self-regulation (Cavallera, Gatto, & Boari, 2014; Ottoni et al., 2012; Owens, Dearth-Wesley, Lewin, Gioia, & Whitaker, 2016) and higher than morning chronotypes on measures of emotional problems (Gau et al., 2007), emotional distress (Giannotti et al., 2002), and depression symptomatology (Pabst, Negriff, Dorn, Susman, & Huang, 2009; Tzischinsky & Shochat, 2011). Evening chronotypes have also been shown to score higher in maladaptive traits pertaining to emotion regulation, such as emotional reactivity, tense arousal, and aggression (Diaz-Morales, Escribano, Jankowski, Vollmer, & Randler, 2014; Schlarb, Sopp, Ambiel, & Grunwald, 2014). Moreover, research

suggests that evening chronotypes may be less adept at up-regulating or maintaining positive mood states, as evidenced by lower amplitude in daily rhythms of positive affect (Hasler et al., 2012; Miller et al., 2015).

Evening chronotypes may also demonstrate implicit cognitive biases toward negative emotional stimuli. For instance, one study found that evening chronotypes, but not morning chronotypes, had quicker recognition of and better memory for stimuli with negative versus positive valence (Berdynaj et al., 2016). According to the process model of emotion regulation (Gross, 1998), selectively attending to negative versus positive stimuli is one of the first determinants of experiencing a negative emotion and how well one is able to self-regulate. *Thus, based on the extant literature, it is highly plausible that greater eveningness would be associated with poorer emotion regulation.*

Design Considerations

Emotion regulation evaluation paradigms

Emotion regulation has been evaluated using several different approaches. Predominantly, laboratory studies have used visual stimuli, stressful tasks, or emotional memory recall to elicit either positive or negative emotions (Webb, Miles, & Sheeran, 2012). Following emotion induction, participants are typically instructed to regulate their emotions using a prescribed cognitive strategy or passively experience their emotions. Emotional responses are often measured via self-report, observed behavior or physiological measures. The difference in emotional response between regulation and passive experience trials is often used to quantify emotion regulation (Hopp, Troy, & Mauss, 2011; Cai, Lou, Long, & Yuan, 2016). Here, we briefly review emotion regulation strategies and the measurement of emotion in laboratory settings.

Emotion regulation strategies. Three broad categories of emotion regulation strategies have been examined in laboratory studies of emotion regulation: 1) attentional deployment, 2) cognitive change, and 3) response modulation (Webb et al., 2012). Attentional deployment requires individuals to distract from an emotion-eliciting stimulus by focusing on alternative thoughts. For instance, participants are often asked to perform mental arithmetic while viewing emotionally charged images (Pena-Sarrionandia, Mikolajczak, & Gross, 2015). Cognitive change involves reinterpreting an emotion-eliciting stimulus. For instance, reframing a negative stimulus in a positive manner, such as envisioning a happy ending for a sad scene (Lerner & Keltner, 2001). Alternatively, a participant could be asked to reinterpret a positive stimulus by thinking about it in terms of personal relevance to increase positive emotional experience (Giuliani, McRae & Gross, 2008). Lastly, response modulation typically involves suppressing an emotional response to a stimulus after it has already been generated. For example, a participant might be asked to smile despite feeling negative, frown despite feeling positive, or reduce his or her heart rate upon feeling aroused (Miyamoto & Ma, 2011). According to the process model of emotion regulation, strategies that are employed earlier on in the time-course of generating an emotion (i.e., attentional deployment or cognitive change) are more successful than attempts to modulate an emotion that has already been generated (i.e., response modulation; Sheppes & Meiran, 2007). Though considered effective and requiring minimal effort, attentional deployment may be maladaptive for dealing with real-world emotional events (Wilson & Gilbert, 2008). Alternatively, cognitive change strategies that involve reappraising emotional information are considered beneficial for long-term emotional health and well-being (Sheppes & Levin, 2013).

More broadly, strengthening cognitive reappraisal skills has been considered one of the most effective components of treatment for a number of psychopathologies (Troy, Wilhelm,

Shallcross, & Mauss, 2010) including alcohol use disorders (Miklowitz et al., 2007). Studies have shown that coping with stressful life events through positive reframing has been associated with fewer substance problems among young adults (Wong et al., 2013). Given the greater effectiveness of early emotion regulation strategies per the process model of emotion regulation and the relevance of cognitive reappraisal for alcohol use problems, we instructed participants to employ the cognitive reappraisal strategy of positive-reframing during an emotion regulation task designed to evaluate both positive and negative emotion regulation ability. Specifically, participants were asked to reframe negative images by thinking about them in a positive manner and to enhance positive images by reframing them in a personally relevant manner.

Affective and physiological definitions of the emotional response. Within emotion regulation paradigms, emotional responses may be measured as affective or physiological. Ideally, both should be measured in emotion regulation studies (Gross, 2002). Affective states are commonly measured via self-report or behavioral observation. Affective states provide insight into the subjective experience of how emotion is being processed. Physiological measures are highly valuable within the study of emotion regulation for two primary reasons. First, self-reported or behaviorally assessed affective states may be more sensitive to demand characteristics during emotion regulation paradigms (Ray et al., 2010). Second, measures of affect and physiology are not always congruent. In fact, some research has shown that less emotionally expressive individuals may be more physiologically reactive to emotion-eliciting stimuli (Quartana & Burns, 2010; Maquet et al., 1995), suggesting that the ability to regulate emotional responses in an experiential or behavioral manner may have consequences for the physiological manifestation of an emotional response (Gross, 2002). Therefore, multiple indices

of emotional responsivity are critical for informing our understanding of emotion regulation in relation to chronotype and alcohol use.

Various physiological indices have been used to measure emotion regulation. Some of the more common methods include electrodermal activity (i.e., skin conductance), electromyography (i.e., startle eyeblink), and cardiovascular or autonomic activity (e.g., heart rate, blood pressure, HRV, and PEP). The current study examined two indices of autonomic functioning, heart rate variability (HRV) and pre-ejection period (PEP) to indicate parasympathetic and sympathetic nervous system activation, respectively.

Autonomic functioning, as measured by HRV and PEP, were chosen for several reasons. Emotions are intrinsically related to physiological arousal, which is largely regulated by the autonomic nervous system (ANS). The sympathetic branch of the ANS is triggered by threatening or arousing stimuli and mobilizes metabolic resources to prepare the body to respond. The vagus nerve of the ANS supplies parasympathetic input to peripheral organs, including the heart, lowering arousal and preparing the body to conserve metabolic resources. Thus, sympathetic activation has been most commonly associated with initiation of negative emotions while vagal parasympathetic inhibition of autonomic arousal has been considered an important process for the down-regulation of negative emotional states (Beauchaine, Katkin, Strassberg, & Snarr, 2001; Thayer, Ahs, Fredrikson, Sollers, III, & Wager, 2012; Lane et al., 2009). However, positive emotion inductions have produced increased parasympathetic activity (McCraty, Atkinson, Tiller, Rein, & Watkins, 1995), while receipt of reward has been associated with reduced sympathetic activation (Beauchaine, Gatzke-Kopp, & Mead, 2007; Beauchaine et al., 2001). Pharmacological blockade studies have validated HRV and PEP as indicators of PNS and SNS functioning, respectively (Hayano, 1991; Sherwood, 1986).

Poor emotion regulation is thought to reflect reduced adaptability to life's demands (Gross & Thompson, 2007). Some have theorized that HRV is a psychophysiological measure of adaptability to environmental stimuli (Porges, 1995), while activation of the SNS, as indicated by PEP, is triggered by environmental threats in order to mobilize resources for fight or flight responses (McLaughlin, Sheridan, Alves, & Mendes, 2014). Research suggests that HRV is correlated with self-reported emotion regulation skills (Talkowski et al., 2006; Smith et al., 2011; Williams et al., 2015; De Witte, Sutterlin, Braet, & Mueller, 2016; Christou-Champi, Farrow, & Webb, 2015; Volokhov & Demaree, 2010). For instance, greater resting time-domain measures of HRV has been associated with lower scores on the Difficulties in Emotion Regulation Scale (DERS; $r=-0.325$, $p<.001$; Williams et al., 2015). Greater power in the high frequency band of HRV (HF-HRV) has also been positively associated with endorsing adaptive interpersonal emotion regulation strategies, such as seeking social support to regulate emotions (De Witte et al., 2016). The literature examining the relationship between PEP and emotion regulation is substantially smaller and mainly limited to young children. However, among children, longer PEP has also been associated with lower emotional reactivity (Clark, Skowron, Giuliano, & Fisher, 2016), and greater SNS recovery from an anger mood induction (as measured by PEP lengthening) has been associated with better parent-reported emotion regulation among children (Kahle, Miller, Lopez, & Hastings, 2015).

From a methodological standpoint, during emotion regulation tasks, HRV and PEP have been shown to be sensitive to emotion-eliciting stimuli (Berna, Ott, & Nandrino, 2014; LeBlanc, Unger, & McNally, 2016; Gendolla & Silvestrini, 2011; Clark et al., 2016) and HRV has been effectively modulated through the use of emotion regulation strategies (Di et al., 2012; Christou-Champi et al., 2015; Francis, Penglis, & McDonald, 2016). Finally, HRV and PEP are non-

invasive, continuous measures of ANS activation that can be measured across short-term intervals (i.e., 1-5 minutes), making them ideal psychophysiological measures to examine across conditions within an emotion regulation paradigm.

Effect Modifiers

Sex. Evening chronotype and alcohol consumption tend to be more prevalent among males. Males consistently report increased preference for evening hours (Randler, 2011a; Adan & Natale, 2002; Tonetti et al., 2008; Cooper et al., 2014; Mukai et al., 2001; Fernandez-Mendoza et al., 2009) and later bedtimes (Burgard & Ailshire, 2013; Asarnow, McGlinchey, & Harvey, 2014; Jankowski, 2015). Similarly, alcohol use and alcohol use disorders tend to be more common among males (Nolen-Hoeksema & Hilt, 2006). Studies examining sex differences in emotion regulation yield inconsistent results (Whittle, Yucel, Yap, & Allen, 2011; Rauer, Kelly, Buckhalt, & El-Sheikh, 2010; McRae, Ochsner, Mauss, Gabrieli, & Gross, 2008; Gardener, Carr, Macgregor, & Felmingham, 2013); however, sex has been shown to moderate associations between emotion regulation and alcohol use. As reviewed by Nolen-Hoeksema (2012), males are more likely to use alcohol as a means of coping with unpleasant emotions (Nolen-Hoeksema, 2012). Therefore, the conceptual model in Figure 1 may be stronger among males. Thus, we examined sex as a moderator of associations between chronotype, alcohol use, and emotion regulation. Exploring sex as a moderator will provide insights into whether the conceptual model proposed earlier (Figure 1) can be applied to males and females, equally.

Sleep duration. Due to the late sleep schedules of evening chronotypes and the early waking schedules required by a majority of social institutions (e.g., school, 9am to 5pm jobs), evening chronotypes tend to be chronically sleep restricted, as evidenced by significantly shorter habitual sleep duration (Kabrita, Hajjar-Muca, & Duffy, 2014; Merikanto et al., 2012; Harvey,

Murray, Chandler, & Soehner, 2011; Korczak, Martynhak, Pedrazzoli, Brito, & Louzada, 2008; Gaina et al., 2006), greater daytime sleepiness (Martin, Gaudreault, Perron, & Laberge, 2016; Gaina et al., 2006; Volk, Dyroff, Georgi, & Pflug, 1994) and greater self-reported sleep complaints (Vitale et al., 2015; Rique, Fernandes Filho, Ferreira, & de Sousa-Munoz, 2014; Kabrita et al., 2014; Merikanto et al., 2012). In particular, sleep on “non-free days”, days when sleep is curtailed in order to meet a social obligation, may be particularly short among evening chronotypes who have difficulty falling asleep until later, regardless of obligations the following day (Roenneberg et al., 2007).

Short sleep duration has been associated with increased alcohol consumption and alcohol use disorder symptoms (Chaput, McNeil, Despres, Bouchard, & Tremblay, 2012). Restricted sleep duration may be associated with greater alcohol use by depleting cognitive executive resources, or higher-order neural processes involved in cognitive control and goal-directed behavior (Verweij et al., 2014; Hahn et al., 2012). For instance, sleep loss has been shown to reduce functional connectivity in prefrontal cortical brain regions necessary for impulse control and decision making (Verweij et al., 2014). Emotion regulation is, in part, a cognitive process that demands executive resources. Emotion regulation is also sensitive to laboratory sleep restriction (Baum et al., 2014; Vriend et al., 2013) and tends to be lower among those who report inadequate sleep (Tavernier et al., 2015). In one study, adolescents who were restricted to 6.5 hours in bed per night for five nights reported significantly reduced emotion regulation ability relative to controls who were allowed 10 hours in bed per night (Baum et al., 2014). Therefore, we examined sleep duration as a moderator of associations among chronotype, alcohol use, and emotion regulation.

Daily positive affect. Positive affect has been found to be significantly higher among morning chronotypes, while no chronotype differences in negative affect have been reported (Hasler et al., 2012; Biss & Hasher, 2012; Dagys et al., 2012; Miller et al., 2015). As previously discussed, alcohol is often used as an external means modulating affect (Howells & Orcutt, 2014; Blevins, Abrantes & Stephens, 2016). Daily baseline positive affect may also be predictive of alcohol consumption. For instance, lower trait positive affect has predicted greater alcohol use (Lopez-Vergara, Spillane, Merrill, & Jackson, 2016). Greater positive affect has “buffered” the association between greater stress and alcohol consumption (McHugh, Kaufman, Frost, Fitzmaurice, & Weiss, 2013). Interestingly, greater positive affect has been associated with greater alcohol consumption and greater self-reported alcohol cravings as well (Patrick, Yeomans-Maldonado & Griffin, 2016; Bold et al., 2016; Peacock et al., 2015; Simons et al., 2005). Therefore, individual differences in daily positive affect may be protective or constitute a risk-factor for greater alcohol use. We explored positive affect as a moderator of associations among chronotype, alcohol use, and emotion regulation.

Personality. Certain personality traits may be important to examine with respect to our conceptual model (Figure 1). For instance, evening chronotypes endorse greater sensation-seeking and impulsivity (Tonetti et al., 2010; Nakazaki et al., 2012; Prather, Bogdan, & Hariri, 2013) which have been independently associated with increased alcohol consumption (Lejuez et al., 2010). Big-5 personality traits such as extroversion have been thought to supersede psychobiological traits such as sensation-seeking and impulsivity (Chapman, Weiss, Barrett, & Duberstein, 2013). In addition, the big-5 personality trait, conscientiousness, is highly associated with morningness (Duggan et al., 2014) and with a lower likelihood of developing alcohol use problems (Hakulinen et al., 2015), while neuroticism is associated with poor emotion regulation

(Cremets et al., 2010). Therefore, the strength of our conceptual model may have depended on the extent to which extroversion, conscientiousness, and neuroticism were represented by our sample. Thus, we evaluated extroversion, conscientiousness, and extroversion as moderators of associations among chronotype, alcohol use, and emotion regulation.

Potential Covariates

Two factors that might confound the interrelationships among our variables of interest are age and psychopathology. Age is a strong correlate of chronotype and alcohol consumption. As we have previously mentioned, chronotype fluctuates across the lifespan (Randler, 2011). A shift toward eveningness begins in the early pre-teen years, plateaus in late adolescence, and remits during the early twenties (Roenneberg et al., 2004). On average, individuals continue to shift toward morningness as they age (Carrier, Monk, Buysse, & Kupfer, 1997). Likewise, dangerous alcohol consumption is most common in late adolescence-early adulthood (US Department of Health and Human Services, 2013). In addition, emotion regulation varies by age with older adults demonstrating greater emotional control relative to younger adults (Gross & Levenson, 1997; Carstensen & Lockenhoff, 2003). To account for age differences, a restricted age-range (i.e., 18-25) was used for this study and age was adjusted for in final statistical models.

Psychopathologies have also been associated with each variable of interest in our model. For instance, mood disorders, such as depression, bipolar disorder, and seasonal-affective disorder, tend to be disproportionately prevalent among evening chronotypes (Antypa et al., 2016; Giglio et al., 2010; Hakkarainen et al., 2003). One examination of mental health and chronotype found that evening chronotypes scored significantly higher on multiple dimension subscales of psychopathology, including but not limited to depression, anxiety, and hostility (Hsu, Gau, Shang, Chiu, & Lee, 2012). Not surprisingly, mood and anxiety disorders are also

major risk factors for substance abuse (Keller, Hanks, & Klein, 1996; Clark et al., 1997) and problems regulating emotions (Cisler & Olatunji, 2012). Common psychopathologies such as mood and anxiety disorders are, therefore, important potential confounds of interrelationships among chronotype, emotion regulation and alcohol use. To account for this possibility, the current study excluded participants on the basis of bipolar I disorder, family history of bipolar disorder, PTSD and severe depression (please see methods for more details). Among participants who did not meet criteria for severe depression, depressive symptoms were controlled for in final statistical models.

Hypotheses

The current study examined chronotype differences in emotion regulation and evaluated the role of emotion regulation in the association between chronotype and alcohol use among males and females between the ages of 18 and 25. Specifically, we sought to replicate findings from the literature regarding the association between chronotype and alcohol use and the association between emotion regulation and alcohol use. In addition, the current study examined affective and autonomic responses to positive and negative stimuli during un-regulated and regulated conditions. Finally, moderation by sex, sleep duration on non-free days, daily positive affect, and three personality traits were explored.

We hypothesized: 1) evening chronotypes would endorse greater alcohol consumption; 2) evening chronotypes would demonstrate poorer emotion regulation; and 3) emotion regulation would mediate the association between chronotype and alcohol use. Finally, sex, sleep duration on non-free days, daily positive affect, and personality traits were evaluated as effect modifiers in three ways: a) moderators of the association between chronotype and alcohol use, b)

moderators of the association between chronotype and emotion regulation, and c) as moderators of the full mediation model.

To test the hypotheses listed above, the current study utilized both field study and laboratory study components. Participants used an online survey system to report their bed and wake times daily for one week and completed a series of questionnaires, including questionnaires to measure chronotype and alcohol use. Following one week, participants came into the laboratory, where we evaluated their performance on an emotion regulation task.

Methods

Participants

Ninety-four undergraduate males and females between the ages of 18 and 25 were recruited for participation. The age-range was chosen because problematic alcohol consumption peaks between the ages of 18-25 (US Department of Health and Human Services, 2013). Similarly, evening chronotype peaks during late adolescence (Roenneberg et al., 2004) and is often highly prevalent among college undergraduates (Lau, Wong, Ng, Hui, Cheung, & Mok, 2013). Males and females were recruited for participation to test whether associations with eveningness were moderated by sex. Participants were recruited through two mechanisms: 1) the University of Pittsburgh, Psychology Department research participant pool which allows students to participate in research studies in exchange for class credit and 2) flyers advertising a research study in need of participants who were “Night Owls” or “Early Birds” were distributed around the University of Pittsburgh. Fifty-five participants were recruited through the research participant pool and 39 participants were recruited as a result of seeing the flyer. The majority of males in this study ($n = 32$, 93.9%) were recruited using the participant pool rather than as a

result of seeing the flyer ($\chi^2 = 26.29, p < 0.001$). No other demographic varied as a function of recruitment method.

Following informed consent, participants were screened for eligibility using the Qualtrics Survey Service. Exclusion criteria included being at risk for bipolar disorder, PTSD, severe depression, and alcohol dependence, as well as self-reported pregnancy, being under the age of 18 or over the age of 25, and self-reported use of a medication that affects autonomic physiology (i.e., beta-blockers, tricyclics, clozapine or thioridazine). Two participants were excluded for severe depression, seven participants were excluded for PTSD and one participant was excluded for co-morbid severe depression, PTSD and bi-polar disorder. All participants excluded for PTSD or PTSD and co-morbid psychopathologies were recruited from the participant pool ($n = 8, 100\%, \chi^2 = 6.20, p = 0.013$). No participants were excluded on the basis of alcohol dependence, pregnancy, age or medications. Three participants were lost to follow-up. Of the 81 eligible participants who completed both field and laboratory phases of the study, three participants had missing data in either autonomic or affective emotion regulation outcome variables (outcome variables are described in detail below under the heading Emotion Regulation). All available data was used for analyses. Total sample sizes for autonomic and affective emotion regulation outcomes were 80 and 79, respectively.

Power Analyses

The needed sample size was estimated based on the model developed by Fritz & MacKinnon (2007) for testing mediated effects. The model estimates minimum sample size needed based on the effect sizes for α and β pathways (Figure 2). In the current study, α represents chronotype differences in emotion regulation and β represents the association between emotion regulation and alcohol use. Because no published papers have explicitly examined

emotion regulation differences across chronotype groups, we used the effect size for chronotype differences in global emotional functioning as a proxy for emotion regulation (Ottoni et al., 2012). The effect size for the β pathway was derived from a study of emotion dysregulation and problematic drinking among undergraduate women (Dragan, 2015). The estimated α and β effect sizes were ≥ 0.39 , indicating moderate effect sizes for both α and β pathways. Per Fritz & MacKinnon (2007), a sample size of 78 was required to find a mediation effect when using the percentile bootstrapping method of identifying indirect effects (Fritz & MacKinnon, 2007).

Procedure

A schematic of the protocol is presented in Figure 3. After signing informed consent, participants completed a series of questionnaires using the Qualtrics Survey Service. Several questionnaires were administered to determine eligibility while others were used for data analysis purposes. Participants meeting inclusion criteria were asked to complete an online diary for seven days, also administered via Qualtrics. Following this seven-day period, participants were asked to come into the laboratory to complete a standardized emotion regulation task. All participants were scheduled for the laboratory component within two hours of their habitual wake-up time, as determined by their 7-day online diary. The laboratory emotion regulation protocol consisted of a 10-minute baseline task, a 22-minute emotion regulation task, administration of several questionnaires and a debriefing. Emotion regulation was measured using a validated emotion regulation paradigm (adapted from Phan and colleagues, 2005). Emotion regulation was conceptualized in two ways: the ability to down-regulate negative emotions and the ability to up-regulate positive emotions. Affect, HF-HRV, and PEP were measured to quantify negative and positive emotion regulation. Affect and autonomic variables

were measured at baseline and throughout the testing period. The laboratory protocol is described in greater detail below.

Screening Questionnaires

The Mood Disorder Questionnaire (MDQ; Hirschfeld et al., 2000). The MDQ is a brief 5-question, 17-item self-report tool designed to screen for the presence of bipolar I disorder. Question 1 lists 13 different symptoms and asks participants to indicate if they have experienced a symptom during “a period of time when they were not their usual self”. Bipolar spectrum disorder is indicated if a participant answers yes to experiencing ≥ 7 of the 13 symptoms in question 1, indicates that ≥ 2 symptoms occurred at the same time, and indicates that at least one of the symptoms they endorsed caused moderate or serious problems in their life via question 3. In our study, participants were also excluded on the basis of potential bipolar disorder if they responded yes to question 4: “Have any of your blood relatives (i.e., children, siblings, parents, grandparents, aunts, uncles) had manic-depressive illness or bipolar disorder?”. Psychometric evaluations of the MDQ have been conducted in both general and clinical populations and have yielded strong specificity (0.67-0.97) and moderate sensitivity (0.28-0.73; Hirschfeld et al., 2000; Hirschfeld, 2002; Miller, Malmstrom, Joshi, Morley, & Wolinsky, 2004; Hirschfeld et al., 2005).

Primary Care PTSD Screen (PC-PTSD; Prins, 2003). The PC-PTSD is a brief 4-item self-report instrument. The presence of PTSD is indicated if a participant has had an experience that was “so frightening, horrible, or upsetting” that it led to ≥ 3 out of 4 common trauma symptoms. The measure has demonstrated very good test-retest reliability (0.83, $p < 0.001$). Sensitivity/specificity values were (0.94/0.92 and 0.70/0.84 for men and women, respectively; Prins, 2003).

The 16-Item Quick Inventory of Depressive Symptomatology (QIDS; Rush et al., 2003). The QIDS is a brief self-report questionnaire that measures severity across nine diagnostic symptom domains: sleep disturbance, psychomotor disturbance, appetite/weight disturbance, depressed mood, decreased interest, decreased energy, worthlessness/guilt, concentration/decision making, and suicidal ideation. The measure demonstrates strong internal consistency (*Chronbach's alpha* = 0.86, Rush, 2003). The QIDS yields scores from 0-27. Scores 16 and above are considered indicative of severe or very severe depression.

Chronotype Measure

Composite Scale of Morningness (CSM; Smith et al., 1989). The CSM is a 13-item questionnaire, designed to be a compilation of the best items from two existing measures, designed to classify an individual across the chronotype spectrum: the Morningness-Eveningness Questionnaire (MEQ; Horne & Ostberg, 1976) and the Diurnal Type Scale (Torsvall & Akerstedt, 1980). The composite questionnaire produces scores that range from 10-56. Current recommendations suggest categorizing chronotypes based on the following cut-off criteria: ≤ 26 evening type, 27-41 intermediate type, and ≥ 42 morning type (Natale & Alzani, 2001). In the current sample, 38.3% ($n = 31$) of participants could be characterized as evening chronotype, 56.8% ($n = 46$) as intermediate chronotype, and 4.9% ($n = 4$) as morning chronotype. To ensure adequate group sizes for comparison analyses, we combined the morning and intermediate chronotypes into one group, referred to from here on out as intermediate chronotypes. Those with CSM scores ≤ 26 ($n = 31$) were categorized as evening chronotypes and those with CSM scores > 26 ($n = 50$) were categorized as intermediated chronotypes.

Alcohol Use Measures

The Alcohol Use Disorder Identification Test (AUDIT; World Health Organization, 2001). The AUDIT is a 10-item questionnaire that probes three domains of alcohol use disorders: hazardous alcohol use, dependence symptoms, and harmful alcohol use. The values for each item are summed yielding scores ranging from 0-40. Total scores of 20 or higher indicate probable alcohol dependence. Continuous AUDIT scores were examined as an outcome in the current study.

7-Day Diary Report of Alcohol Use. Daily alcohol use was also measured using a daily diary to assess the association between chronotype daily alcohol consumption patterns. A Qualtrics-based, electronic, time-stamped daily diary was sent to participants each morning and participants were instructed to complete the diary entries within the first hour of waking up. Participants entered the number of alcoholic beverages consumed the day before into the daily diary. Mean alcoholic drinks consumed across the 7-day data collection was analysed as a measure of daily alcohol consumption.

Other Questionnaires

Demographics – A brief questionnaire was administered to participants to collect data on age, sex, gender, pregnancy, race, ethnicity and whether or not participants were taking a medication that could affect autonomic functioning. The demographic data was used to determine eligibility and during the analysis stage of the study.

7-Day Diary Report of Sleep Duration. Using the Qualtrics diary described under alcohol use measures, participants recorded daily bed times, wake times, how long it took them to fall asleep (a.k.a. sleep latency, SL), and number of minutes spent awake after initial sleep onset (WASO). Habitual sleep duration was measured as the number of minutes between bed

and wake times minus SL and WASO. Each day, participants indicated whether they had a “free day”, meaning they were able to sleep in, or if they had a “non-free day”, meaning they needed to wake up early in order to meet an obligation such as attending a morning class or going to work. Because sleep on non-free days tends to be more curtailed among evening chronotypes (Roenneberg et al., 2007), we examined non-free day sleep duration as a moderator of associations among chronotype, alcohol use, and emotion regulation (described in detail under the Statistical Analysis section).

44-Item Big Five Inventory of Personality (The Big Five; John, Donahue & Kentle, 1991) – The Big Five is a 44-item questionnaire that measures five personality dimensions: openness, conscientiousness, extroversion, agreeableness, and neuroticism. Participants are asked to mark the extent to which they agree with 44 statements on a scale of 1 to 5 anchored by “disagree strongly” and “agree strongly”. Subscales are created for each of the five personality dimensions. Due to their associations with chronotype (Duggan et al., 2014), alcohol use (Hakulinen et al., 2015; Fairbairn, Sayette, Wright, Levine, Cohn, & Creswell, 2015), and emotion regulation (Cremets et al., 2010), we limited our analyses to examine the moderating role of conscientiousness, extroversion, and neuroticism.

Laboratory Emotion Regulation Protocol

All participants were scheduled for their laboratory emotion regulation protocol within two hours of their habitual wake-up time, as measured by their week-long sleep diary. On average, participants began the laboratory emotion regulation protocol 1.06 ± 0.94 hours later than their average wake up time. The laboratory emotion regulation protocol consisted of a baseline assessment period and an emotion regulation testing period. Participants were asked to abstain from drinking alcohol or caffeine and from exercising 12 hours prior to their scheduled

testing session and asked to abstain from smoking 4 hours prior to their testing session. This was verified by self-report at the time of laboratory testing.

Baseline. Participants were instructed to view a screen showing a series of colored blocks for a 10-minute period. Participants were asked to attend to the colored blocks and count the number of times they saw the first colored block that appeared on the screen. This baseline task has been shown to be an effective method for washing-out individual differences in physiological arousal that might be present upon coming into the lab (Jennings, Kamarck, Stewart, Eddy, & Johnson, 1992).

Emotion regulation task. Participants viewed a series of neutral, negative, and positive images. Participants viewed 10 blocks of images. Each block was comprised of 12 positive, 12 negative, *or* 12 neutral images (Figure 4). Images within each block were preceded by one of three cues: “look”, “reframe”, or “enhance”. Prior to the task, participants were instructed on what to do after seeing each cue. When cued to “look”, participants were instructed to view the image while experiencing their emotions naturally. When cued “reframe”, participants were instructed to reappraise the image’s meaning in a more positive way such as envisioning a happy ending to a sad scene. When participants were cued to “enhance”, they were instructed to increase their positive response to the image by thinking about it in a more personally relevant manner. Cues were presented for 1500 milliseconds. Each image was presented for 6000 milliseconds. Following each image, participants had 3000 milliseconds to rate how they felt on a scale ranging from “extremely negative” to “extremely positive” (for example in Figure 5). Each block of 12 images was completed in just over 2 minutes. Positive, negative and neutral image blocks were presented in pseudorandom order, with the first block always being neutral to

establish baseline measures of affect and autonomic physiology. Images were presented to participants using the e-Prime software (Schneider, Eschman, & Zuccolotto, 2007).

Image selection. Images were selected from the International Affective Picture System (IAPS; Lang, Greenwald, Bradley, & Hamm, 1993). The IAPS is a database developed by the Center for the Study of Emotion and Attention at the University of Florida. The IAPS contains color photographs that have been rated on dimensions of arousal and valence, yielding normative arousal and valence ratings for each image. Images from the IAPS have been validated as effective stimuli to evoke emotional responses.

A total of 24 negative images, 24 positive images, and 24 neutral images were selected from the database. To select images, the database was sorted by valence and then by category (e.g., burn victims, snakes, puppies, attractive females). The most negatively and positively rated images for each category were selected for consideration. We selected images from each category to avoid over-selecting images from only the most negatively rated category (i.e., burn victims) or most positively rated category (i.e., puppies). Images from one singular category might elicit a specific type of emotion such as disgust or affection. Our intention was to elicit negative and positive emotions broadly. The 24 images of each type (i.e., negative, positive, and neutral) were divided into two separate blocks of 12 images each that did not differ in term of database valence and arousal ratings.

Operationalization of emotion regulation. Emotion regulation was measured using three outcomes: self-reported affect, HF-HRV, and PEP. All three outcome variables were measured during 2 neutral “look” trials, 2 negative “look” trials, 2 positive “look” trials, 2 negative “reframe” trials, and 2 positive “enhance” trials (Figure 4). Outcome variables were averaged across like trials. Emotion regulation was operationalized as the difference in average outcome

variable between trials when participants were passively viewing pictures (i.e., “look” trials) and trials during which participants were viewing pictures while actively attempting to regulate their emotions (i.e., “reframe” and “enhance” trials). For example, negative emotion regulation via self-reported affect (N-ER-SRA) was calculated by subtracting average self-reported affect during negative “look” trials from average self-reported affect during “reframe” trials (Table 1). Because we anticipated that affect will become more positive during “reframe” trials, greater values reflect better emotion regulation. Similarly, positive emotion regulation via self-report (P-ER-SRA) was calculated by subtracting self-reported affect during positive “look” trials from affect during “enhance” trials. Again, greater differences in self-reported affect reflect better affective emotion regulation. Please see the key in Table 1.

Physiology

Heart rate variability (HRV). Heart rate variability is a measure of autonomic physiology that can be measured in time and frequency domains. The high frequency component of HRV (HF-HRV) was used as a physiological marker of emotional response for the following reasons. In contrast to time-domain measures of HRV, spectral components, such as power in the high frequency band (0.15 to 0.40 Hz) can be obtained from short-term recordings (e.g., 1-5 minutes; European Task Force Society of Cardiology & the North American Society of Pacing & Electrophysiology, 1996; Pinna et al., 2007).

Experimental studies show that the high frequency component of HRV is regulated by efferent vagal signaling (Malik & Camm, 1993), indicating regulation of the cardiovascular system via the parasympathetic nervous system (PNS). Activation of the PNS is essential for inhibiting heightened states of arousal (Beauchaine, 2001; Thayer et al., 2012; Lane et al., 2009). In contrast, the precise origins of the low frequency components of HRV (LF-HRV) are less

understood (European Task Force Society of Cardiology & the North American Society of Pacing & Electrophysiology, 1996). Although LF-HRV has traditionally been thought to correspond with SNS activation, more recent analysis suggests that LF-HRV is largely regulated by the PNS along with the other components of HRV (Reyes del Paso, Langewitz, Mulder, van, & Duschek, 2013). In addition, LF-HRV appears to be more sensitive than HF-HRV to respiratory rate (Pinna et al., 2007). Therefore, HF-HRV was chosen as a more reliable signal for measuring physiology during the laboratory emotion regulation protocol. In the current study, greater difference in HF-HRV between “look” and either “reframe” or “enhance” blocks represents greater emotion regulation at the physiological level.

Pre-ejection period (PEP). Pre-ejection period (PEP) is a measure that reflects activation in the sympathetic branch of the ANS. Precisely, PEP is the time between depolarization of the left ventricular myocardium and the opening of the aortic valve. Pharmacological studies have validated PEP signal as a reliable estimate of peripheral SNS activation (Schachinger, Weinbacher, Kiss, Ritz, & Langewitz, 2001). Specifically, epinephrine administration has resulted in shortened PEP while administration of the beta-blocker, esmolol, has resulted in PEP lengthening (Schachinger et al., 2001).

Better emotion regulation has been associated with longer PEPs. For instance, better parent-reported emotion regulation is associated with PEP lengthening following anger induction in children (Kahle et al., 2015). Another study reported that PEP shortened when participants were asked to up-regulate, or exaggerate, their emotional response to sad film clips (Robinson & Demaree, 2009). However, other studies have shown no difference in PEP when participants attempted to regulate their emotions (Crowell, Beauchaine, McCauley, Smith, Stevens, & Sylvers, 2005; Musser, Backs, Schmitt, Ablow, Measelle, & Nigg, 2011). In the current study,

better emotion regulation will be indicated by PEP lengthening from negative “look” to negative “reframe” trials and from positive “look” to positive “enhance” trials.

HRV and PEP data acquisition and processing. Data were collected using Mindware Bionex hardware (Mindware, Gahanna, OH). Simultaneous electrocardiogram (ECG) and impedance cardiogram (ICG) were measured. The ECG and ICG signals were used to compute HRV and PEP. Both ECG and ICG are non-invasive continuous measures of autonomic functioning. The ECG was obtained via three spot electrodes on the front of the torso. The ICG was obtained via four spot electrodes: one on the jugular notch, one below the sternum, and two on the spine 1.5 inches above and below the front spot electrodes. Signals were collected in 126 second epochs.

Mindware HRV 3.1 and IMP 3.1 software were used to calculate HF-HRV and PEP values. The HF-HRV data was derived through automatic detection of R-peaks. Automatic detection was visually inspected for R-peak identification errors and manually corrected. Spectral power in the 0.15 Hz to 0.40 Hz range was calculated using fast Fourier transformation of the interbeat interval. A Hamming window was used to detrend, center and taper the interbeat interval series. The PEP values were derived from the ECG and ICG signals. Mindware software IMP 3.1 was used to automatically detect the ECG Q point (ventricular depolarization onset) and the dZ/dt B point (opening of aortic valve). Ensemble averages produced by the software were manually inspected and Q and B points were adjusted in less than 10% of cases according to established correction methods (Berntson, Lozano, Chen, & Cacioppo, 2004; Lozano et al., 2007).

Statistical Analysis

Hypothesis 1 – Alcohol Use will be Significantly Greater Among Evening Chronotypes

General linear models were used to compare chronotype group means on both AUDIT-assessed and diary-assessed alcohol consumption while controlling for age and depressive symptoms.

Hypothesis 2 – Emotion Regulation will be Significantly Worse Among Evening Chronotypes

A total of 6 emotion regulation variables (i.e., SRA, HRV, and PEP during negative emotion regulation and SRA, HRV, and PEP during positive emotion regulation) were compared between evening intermediate chronotypes using a general linear model controlling for age and depressive symptoms. We hypothesized that evening chronotypes would exhibit poorer emotion regulation as measured by smaller differences in affective and autonomic responding between “look” trials and and trials wherein participants were asked to either down-regulate negative emotions (“reframe” trials) and up-regulate positive emotions (“enhance” trials). For analyses examining PEP during negative emotion regulation, a natural log transformation was used on N-ER-PEP, correcting the skew statistic from -4.369 to 0.484). All other emotion regulation variables were skewed < 2.0.

Hypothesis 3 – Evening Chronotype will be Indirectly Associated with Greater Alcohol Consumption via Poor Emotion Regulation

The percentile bootstrapping method, developed by Shrout and Bolger (2002) was proposed to test whether there was an indirect effect of chronotype on alcohol use via emotion regulation (Shrout & Bolger, 2002a). The percentile bootstrapping method is a statistically powerful alternative to traditional mediation methods such as the Barron and Kenny (1986)

approach and the Sobel test of mediation (Sobel, 1982; MacKinnon, 2004}. Bootstrapping methods involve forming a set of unique samples by sampling from the original sample set with continuous replacement. A parameter, such as an indirect effect, is calculated for each new sample and a bootstrap distribution for that parameter is formed. This accounts for asymmetries in the distribution of indirect effects. As reviewed by Shrout and Bolger (2002), confidence intervals of indirect effects tend to be skewed in favor of the null hypothesis, leading to greater risk for Type II errors (Shrout & Bolger, 2002). The Baron and Kenny (1986) and Sobel (1982) methods assume a symmetric distribution around the standard error of the mediated effect (Mallinckrodt, Abraham, Wei, & Russell, 2006} and are, therefore, most appropriate for use with large sample sizes (Henderson et al., 1995). The percentile bootstrapping method is thought to increase statistical power when either sample size or effect sizes are small (Shrout & Bolger, 2002). Mediation analyses would only be performed if the indirect pathway ($\alpha\beta$, Figures 1 and 2) was significant (Baron and Kenny, 1986; Zhao, Lynch, & Chen, 2010).

Exploratory Aim Analyses - Evaluate if the indirect effect of chronotype on alcohol use via emotion regulation is conditional upon sex, habitual sleep duration on non-free days, positive affect, extroversion, conscientiousness, and/or neuroticism.

In an exploratory fashion, we tested whether the direct effect τ (the direct association between chronotype and alcohol use, depicted in Figures 1 and 2), mediation pathway α (the effect of chronotype on emotion regulation; depicted in Figures 1 and 2), and/or mediation pathway β (the effect of emotion regulation on alcohol use; depicted in Figures 1 and 2) were moderated by sex, sleep duration on non-free days, positive affect, extroversion, conscientiousness, or neuroticism. Finally, exploratory moderated mediation analyses were conducted to test if an indirect association between chronotype and alcohol use via emotion

regulation varied as a function of the moderating variables. According to the process outlined by Muller, Judd, and Yzerbyt (2005), moderated mediation was only tested when an exploratory variable significantly moderated the α pathway, the β pathway, or both (Figure 6). When appropriate, moderated mediation was run on 1,000 bootstrapped samples. The 95% confidence interval for the distribution of each conditional indirect effect was examined. Upper and lower bounds of the 95% confidence interval containing zero indicate that the conditional indirect effect is non-significant at $p > 0.05$.

Alternative Design Considerations

The primary aim of the current study was to evaluate the indirect association between chronotype and alcohol use through emotion regulation. The methods proposed here were designed to optimize external validity, innovation and feasibility. However, we acknowledge that there are alternative methodological approaches that could have been used in service of our primary aim. Several alternative approaches are considered here.

Why not study extreme evening and morning chronotypes only? Many chronotype studies have established chronotype groups in one of two ways: 1) using pre-determined cut-off scores on a chronotype measure (e.g., CSM scores ≤ 26 evening chronotype; 27-41 intermediate chronotype; ≥ 42 morning chronotypes); or 2) after a sample has been collected, categorizing participants as evening or morning chronotypes if they fall into the 10th and 90th percentiles of the sample distribution. For both approaches, large samples are needed to acquire a sufficient number of participants in each chronotype group. The current study relied on recruiting participants from the University of Pittsburgh undergraduate Psychology program participant pool which was limited in size. In addition, students in the participant pool were required to complete four credit hours of research in the same semester in which they enrolled. Based on

these limitations, the current study compared evening chronotypes to non-evening chronotypes (i.e., morning and intermediate). This approach is relevant for college populations who tend to be either evening oriented or assume a later sleep schedule simply due to the evening oriented culture that dominates college campuses (Lau et al., 2013).

Why not use a within-subject design to test emotion regulation during morning and evening sessions? Testing emotion regulation during a morning session and an evening session was considered. Because chronotypes are partially defined by self-reported timing of peak cognitive functioning and emotion regulation is, in part, a cognitive process, it stands to reason that chronotypes may exhibit stronger emotion regulation at their preferred time of day. Despite this reasonable logic, studies examining chronotype by time-of-day effects in emotional responding have not produced compelling results.

Specifically, four studies have examined chronotype differences in stress reactivity during both morning and afternoon testing sessions (Roeser, Oberqfell, Meule, Vogeles, Schlarb, & Kubler, 2012; Willis, O'Connor & Smith, 2005; Nebel et al., 1996; Dunn & Taylor, 2014). One out of four studies found a time-of-day effect for stress reactivity, showing that cardiovascular reactivity was stronger in the afternoon relative to the morning; this effect was not different in intermediate and evening chronotypes (Roeser et al., 2012). Nebel et al (1996) and Dunn et al (2014) did find interactions between chronotype and time-of-day; however, the results of the two studies conflicted with one another. One showed that stress reactivity was highest when chronotypes were tested at their preferred time (Nebel et al., 1996) and the other found that stress reactivity was highest at chronotypes' non-preferred time (Dunn & Taylor, 2014).

Only one study has examined time-of-day effects on emotion regulation and found that emotion regulation did fluctuate across the day in accordance with hypothesized age-related

peaks in cognitive performance (Tucker, Feuerstein, Mende-Siedlecki, Ochsner, & Stern, 2012). Specifically, older adults and younger adults completed an emotion regulation task once in the morning and once in the afternoon. Older adults demonstrated greater difficulties with emotion regulation during the afternoon session while the opposite was true for younger adults.

Hasler and colleagues (2012) has shown chronotype differences in positive affect rhythms across the day (Hasler et al., 2012). The study found no chronotype differences in negative affect rhythms. Results of this study provide some suggestion that positive but not negative emotion regulation may show time-of-day effects with respect to chronotype. Therefore, testing positive emotion regulation during a standardized time-window may artificially inflate differences between chronotype groups. To account for this possibility, the laboratory emotion regulation protocol was scheduled based on each participant's habitual wake-up time. Participants were tested at their subjective morning time rather than a standardized clock time. Post-hoc analyses were conducted to assess whether time of day moderated associations between chronotype and emotion regulation.

Results

Among the eighty-one participants who completed the study, the average age was 19.63 \pm 1.17, 67.9% ($n = 55$) were female, 69.1% ($n = 56$) were Caucasian, and 97.5% ($n = 79$) identified as Non-Hispanic or Latino (see Table 2 for complete demographic data). Average sleep duration was 8.12 hours \pm 70 minutes on free days and 6.74 hours \pm 79 minutes on non-free days. Average sleep midpoint was 6:04 am \pm 95 minutes on free days and 4:53 am \pm 62 minutes on non-free days.

Evening and intermediate chronotypes did not differ in terms of age, sex, or race. Diary-assessed sleep midpoints on both free and non-free days were significantly later among evening

chronotypes relative to intermediate chronotypes ($F = 22.783, p < 0.001$ and $F = 13.559, p < 0.001$, free and non-free, respectively; Table 2). Sleep duration on non-free but not free days was also significantly shorter among evening chronotypes ($F = 10.555, p = 0.002$). Screening measures of depressive symptoms, mood disorder symptoms, and symptoms of PTSD did not differ between chronotype groups.

Manipulation Checks

Manipulation checks revealed that emotion regulation successfully altered affective but not autonomic responses to negative stimuli (see Table 3). Specifically, while viewing negative images, self-reported affect was significantly more negative during “look” trials relative to “reframe” trials ($t = -15.274, p < 0.001$). There was a slight difference in PEP between negative “reframe” and “look” trials such that PEP was shorter when participants were trying to reframe negative images in a positive way as compared with passively viewing negative images; however, this difference did not reach statistical significance ($t = 1.832, p = 0.071$). There was no significant differences in HF-HRV between negative “look” and “reframe” trials. Emotion regulation also successfully altered affective but not autonomic responses to positive stimuli. Self-reported affect was significantly more positive during “enhance” trials relative to “look” trials ($t = -13.671, p < 0.001$). There were no differences in HF-HRV nor PEP between “look” and “enhance” trials. Please see Appendix Tables A1-A3 for correlations between affective and autonomic variables within each trial type.

Hypothesis 1 – Alcohol Use will be Significantly Greater Among Evening Chronotypes

Self-reported alcohol consumption was fairly low within the sample. Participants reported an average consumption of 0.72 ± 0.84 drinks per day with an average of 4.99 ± 6.04 drinks total across the 7-day diary field assessment (Table 2). AUDIT scores ranged from 0 to 18

($mean = 5.19 \pm 3.83$). Diary-assessed alcohol consumption did not differ between chronotype groups (Table 4). However, AUDIT scores were significantly higher among evening chronotypes, before and after controlling for age and depressive symptoms ($F = 4.919$, $p = 0.029$ and $F = 4.399$, $p = 0.039$, respectively).

Hypothesis 2 – Emotion Regulation Will be Significantly Worse Among Evening Chronotypes

Self-reported affect. Chronotype was unrelated to changes in self-reported affect (SRA) during both negative and positive emotion regulation. Specifically, when viewing negative images, the difference in SRA between “look” and “reframe” trials did not vary by chronotype group (Table 5). Similarly, when viewing positive images, the difference in SRA between “look” and “enhance” trials did not vary by chronotype group (Table 6).

High-frequency heart rate variability. Chronotype was unrelated to changes in HF-HRV during both negative and positive emotion regulation trials. Specifically, when viewing negative images, the difference in HF-HRV between “look” and “reframe” trials did not vary by chronotype group (Table 5) and when viewing positive images, the difference in HF-HRV between “look” and “enhance” trials did not vary by chronotype group (Table 6).

Pre-ejection period. Chronotype was also unrelated to changes in PEP during both negative and positive emotion regulation. Specifically, when viewing negative images, the difference in PEP between “look” and “reframe” trials did not vary by chronotype group (Table 5). Similarly, when viewing positive images, the difference in PEP between “look” and “enhance” trials did not vary by chronotype group (Table 6).

Hypothesis 1 predicted that evening chronotypes would endorse more symptoms of alcohol use disorder and would report greater alcohol consumption on a 7-day diary. Our data

partially supported this prediction. AUDIT-assessed symptoms of alcohol use disorder were significantly higher among evening compared to intermediate chronotypes. Hypothesis 2 predicted that evening chronotypes would be less successful at regulating affective and autonomic responses to negative and positive emotional stimuli. Our data showed no differences in emotion regulation between intermediate and evening chronotypes. There were also no associations between emotion regulation and either measure of alcohol consumption (Appendix Table A4). Based on these results, there was no justification to test the mediation model depicted in Figure 1 (Hypothesis 3; Baron & Kenny, 1986; Zhao, Lynch, & Chen, 2010).

Exploratory Moderation Analyses

Sex. Sex did not vary by chronotype (Table 2). Neither diary- nor AUDIT-assessed alcohol use varied by sex (Appendix Table A5). Moderation analyses revealed no sex by chronotype interaction on diary- nor AUDIT-assessed alcohol use ($F = 0.735$, $p = 0.394$ and $F = 1.572$, $p = 0.214$, respectively, Table 7). Females reported feeling significantly more negative than males while viewing negative images during “look” trials ($F = 11.262$, $p = 0.001$; Appendix Table A6). Females had significantly higher N-ER-SRA relative to males ($F = 3.951$, $p = 0.050$; Appendix Table A7), indicating that females demonstrated significantly better affective regulation during negative emotion regulation. However, sex did not moderate associations between chronotype and any of the six emotion regulation variables (Table 8). Finally, sex did not moderate associations between emotion regulation and either alcohol use measure (Appendix Table A8).

Sleep duration on non-free days. As shown in Table 2, sleep duration on non-free days was significantly shorter among evening chronotypes compared to intermediate chronotypes. Sleep duration on non-free days was unrelated to AUDIT- and diary-assessed alcohol

consumption (Appendix Table A9). Sleep duration on non-free days did not moderate associations between chronotype and either diary- or AUDIT-assessed alcohol consumption (Table 7).

There was no main effect of sleep duration on non-free days on affective or autonomic measures of emotion regulation (Appendix Table A10). Moderation analyses revealed a significant interaction between sleep duration on non-free days and chronotype on N-ER-HRV ($\beta = 0.365, p = 0.039$; Table 9). Specifically, longer sleep duration on non-free days was associated with increases in HF-HRV between “look” and “reframe” trials for intermediate chronotypes but not for evening chronotypes (see Figure 7). This interaction was robust to adjustment for age and depressive symptoms ($\beta = 0.369, p = 0.05$). Sleep duration on non-free days did not moderate associations between chronotype and any other measures of emotion regulation, nor did sleep duration moderate associations between emotion regulation and alcohol use (Appendix Table A11). Because sleep duration on non-free days moderated the association between chronotype and N-ER-HRV, moderated mediation was tested. The results were non-significant (Appendix Tables A12).

Positive affect. Daily positive affect was slightly higher among intermediate chronotypes compared with evening chronotypes ($F = 3.274, p = 0.074$; Table 2). Positive affect was unrelated to AUDIT- and diary-assessed alcohol consumption (Appendix Table A8). Positive affect did not moderate associations between chronotype and either AUDIT- nor diary-assessed alcohol consumption (Table 7).

Daily positive affect was unrelated to affective and autonomic outcomes during negative emotion regulation trials (Appendix Table A10), nor did daily positive affect moderate associations between chronotype and any indices of negative emotion regulation (Table 10).

Positive affect was unrelated to P-ER-SRA and P-ER-HRV; however, greater daily positive affect was negatively associated with P-ER-PEP (Appendix Table A10). Specifically, greater daily positive affect was associated with PEP shortening during “enhance” trials. Moderation analyses showed that positive affect did not moderate associations between chronotype and any measure of positive emotion regulation (Table 10). Finally, positive affect did not moderate associations between emotion regulation and either alcohol use measure (Appendix Table A13).

Conscientiousness. Intermediate chronotypes were significantly higher in conscientiousness compared to evening chronotypes ($F = 8.743, p = 0.004$, Table 2). Conscientiousness was unrelated to AUDIT scores and diary-assessed alcohol consumption (Appendix Table A8). Conscientiousness did not moderate associations among chronotype and either alcohol consumption measure (Table 7).

Conscientiousness was unrelated to affective and autonomic outcomes during negative emotion regulation (Appendix Table A10), nor did conscientiousness moderate associations between chronotype and any measure of negative emotion regulation (Table 11). Similarly, conscientiousness was unrelated to affective and autonomic outcomes during positive emotion regulation (Appendix Table A10), nor did conscientiousness moderate associations between chronotype and any measure of positive emotion regulation (Table 11). Conscientiousness did not moderate associations between emotion regulation and alcohol use (Appendix Table A14).

Extroversion. Extroversion was unrelated to chronotype (Table 2) and unrelated to AUDIT- and diary-assessed alcohol consumption (Appendix Table A8). Extroversion did not moderate associations between chronotype and either measure of alcohol consumption (Table 7).

Extroversion was unrelated to affective and autonomic measures of negative emotion regulation (Appendix Table A10) and did not moderate associations between chronotype and

measures of negative emotion regulation (Table 12). Similarly, extroversion was unrelated to positive emotion regulation outcomes and extroversion did not moderate associations between chronotype and any measure of positive emotion regulation (Table 12). Extroversion did not moderate associations between emotion regulation and alcohol use (Appendix Table A15).

Neuroticism. Neuroticism was unrelated to chronotype (Table 2) and both AUDIT- and diary-assessed alcohol consumption (Appendix Table A8), nor did neuroticism moderate associations between chronotype and either measure of alcohol consumption (Table 7).

Neuroticism was unrelated to N-ER-SRA and N-ER-HRV. In contrast, neuroticism was associated with negative emotion regulation, as measured by changes in PEP (N-ER-PEP). Specifically, greater neuroticism was associated with PEP shortening when participants were asked to “reframe” negative images ($r = -0.293$, $p = 0.010$; Appendix Table A9). During positive emotion regulation trials, neuroticism was unrelated to P-ER-SRA and P-ER-HRV. However, neuroticism was associated with P-ER-PEP. Specifically, greater neuroticism was associated with PEP lengthening when participants were asked to “enhance” positive images ($r = 0.299$, $p = 0.009$; Appendix Table A10). Neuroticism did not moderate associations between chronotype and any measure of emotion regulation (Table 13). Neuroticism did not moderate associations between emotion regulation and alcohol use (Appendix Table A16).

Post-Hoc Time-of-Day Analyses

Time of day at which the laboratory protocol took place was not related to N-ER-SRA, N-ER-HRV, or any measure of positive emotion regulation. Later time of day was associated with greater lengthening of PEP during negative emotion regulation trials ($r = 0.248$, $p = 0.033$; Appendix Table A17). Time of day also moderated the association between chronotype and N-ER-HRV (Figure 8). Specifically, evening chronotypes with earlier task-start times exhibited

better negative emotion regulation, as indicated by greater increases in HF-HRV during “reframe” trials ($\beta = 0.347, p = 0.047$; Table 14). This interaction was robust to adjustment for covariates ($\beta = 0.363, p = 0.044$). Finally, a moderated mediation analysis demonstrated that time of day did not moderate indirect effects of chronotype on AUDIT scores via N-ER-HRV (Appendix Tables A18).

Discussion

The overall goal of the study was to evaluate emotion regulation as a pathway linking chronotype to alcohol use. Specifically, we tested three primary hypotheses: 1) eveningness would be associated with greater alcohol use; 2) eveningness would be associated with poorer emotion regulation; and 3) emotion regulation would mediate the association between eveningness and alcohol use. Our data supported Hypothesis 1; evening chronotypes endorsed greater symptoms of alcohol use disorder compared to intermediate chronotypes. Hypothesis 2 was not confirmed. Chronotype was unrelated to changes in self-reported affect, HF-HRV and PEP during both negative and positive emotion regulation. Because there was no association between chronotype and emotion regulation, we were unable to test our conceptual model (Hypothesis 3; Figure 1).

Exploratory analyses revealed a significant interaction between chronotype and sleep duration on non-free days in relation to negative emotion regulation as measured by changes in HF-HRV. Among intermediate chronotypes, longer sleep duration on non-free days was associated with increases in HF-HRV during negative emotion regulation. No such effect was observed for evening chronotypes. Finally, a post-hoc analysis revealed that evening chronotypes who were tested earlier in the day had better negative emotion regulation as measured by

changes in HF-HRV. Our findings are discussed within the context of the broader literature below.

Chronotype & Alcohol Use

Evening chronotype was associated with higher scores on the AUDIT. This finding is consistent with a growing body of literature that shows significant associations between eveningness and greater alcohol consumption. Of 28 studies, reviewed elsewhere (Taylor et al., under review at Sleep Medicine Reviews), only three reported no association between evening chronotype and greater alcohol use (Haraszti, Purebl, Salavecz, Poole, Dockray, & Steptoe, 2014; Nowakowska-Domagala, Mokros, Jablkowska-Gorecka, Grzelinska, & Pietras, 2016; Culnan, Kloss, & Grandner, 2013). For instance, Haraszti and colleagues (2014) found no chronotype group difference in self-reported alcohol consumption among 202 female professionals (Haraszti et al., 2014). A study of 58 alcohol-dependent men and 29 healthy controls showed no chronotype group differences in level of alcohol dependence, as measured by the Michigan Alcoholism Screening Test (MAST; Selzer, 1971; Nowakowska-Domagala, 2016). Finally, Culnan, Kloss, and Grandner (2013) studied prospective associations between chronotype and various health behaviors among 137 incoming college freshmen during the second week of school and again eight weeks later (54 were studied at follow-up; Culnan et al., 2013). The investigators found no association between chronotype and alcohol consumption at baseline; however, among the 54 who completed the follow-up assessment, evening chronotypes reported significantly more drinking than morning chronotypes, presumably after acclimating to college life.

Our findings contribute to the literature on chronotype and alcohol use by showing that evening chronotypes endorsed more symptoms of alcohol use disorder but did not report greater

daily alcohol consumption. Most studies examining chronotype in relation to alcohol use have measured either daily consumption or self-report measures of abuse, such as the AUDIT, though few have measured both. Our findings provide greater detail regarding alcohol use among undergraduate evening chronotypes.

The majority of participants in our sample were under the legal drinking age ($n = 75$, $79.8\% < 21$ years old). Underage drinkers, who do not have consistent access to alcohol and, therefore, drink on fewer occasions, are also more likely to binge drink relative to legal-age drinkers (Weschler, Lee, Nelson, & Kuo, 2002). Therefore, underage drinkers may be more likely to report greater frequency in response to questions such as, “How often do you have six or more drinks on one occasion” than they are to report drinking on a daily basis over a 7-day period. It is, thus, plausible that the AUDIT was more sensitive to the drinking behaviors and patterns of the underage sample enrolled in this study. Furthermore, the pattern of data presented here may indicate that a 7-day diary assessment may not be a sufficient observation period to accurately assess alcohol consumption level within the age-group.

Chronotype & Emotion Regulation

Contrary to expectations, there were no main effects of chronotype on emotion regulation. As stated previously, we anticipated that evening chronotypes would exhibit poorer emotion regulation given previous work showing that evening chronotypes score higher on measures of emotional lability, emotional distress and emotional problems (Jeong Jeong et al., 2015; Giannotti et al., 2002; Gau et al., 2007), and score lower on measures of emotional stability and control (Cavallera et al., 2014; Ottoni et al., 2012). Evening chronotypes have also been shown to score higher on measures of emotional reactivity, tense arousal and aggression

(Diaz-Morales, Escribano, Jankowski, Vollmer, & Randler, 2014; Schlarb, Sopp, Ambiel, & Grunwald, 2014).

The lack of chronotype differences in emotion regulation was likely due to the fact that, within the sample as a whole, the presence of emotion regulation was only verified by self-report and was not evident from measures of autonomic physiology. Therefore, it is possible that successful emotion regulation as seen by change in self-reported affect may merely reflect the influence of demand characteristics (Ray, McRae, Ochsner, & Gross, 2010). While numerous emotion regulation studies have used similar experimental paradigms to effectively regulate physiological measures (Wu, Winkler, Wieser, Andreatta, Li, & Pauli, 2015; Di Simplicio, Costoloni, Western, Hanson, Taggart, & Harmer, 2012; Christou-Champi et al., 2015), other studies have found that instructions to regulate emotions had the intended impact on self-reported emotions but not on physiology (Pedersen & Larson, 2016). Differences in manipulation success may be due to slight variations in protocol and length of time participants were given to practice emotion regulation strategies. For instance, in one study, one group of participants were given three training sessions on three separate days, prior to the laboratory emotion regulation task (Christou-Champi et al., 2015). Those who participated in training sessions successfully increased HRV while “reappraising” negative images, while those in a control group who received no training, exhibited no change in HRV.

Individual differences in interoceptive awareness, the extent to which one is conscious of bodily signals, may have also contributed to the differences in manipulation success. For instance, greater interoceptive awareness has been associated with activation in neural regions associated with down-regulating negative emotional states (Fustos, Gramann, Herbert, & Pollatos, 2013). Increasing interoceptive awareness through bio-feedback has also been shown to

improve cardiovascular reactivity to negative emotional stimuli (Peira, Fredrikson, & Pourtois, 2014). Future studies should measure interoceptive awareness to better understand discrepant findings across affective and physiological outcomes.

The null findings reported here may have also been due to a lack of emotional arousal induced by our stimuli (Appendix Table A19). When compared to outcomes measured while viewing neutral images, only self-reported affect changed upon viewing emotionally charged images. Lack of emotional reactivity may have resulted from our decision to choose pictures from the IAPS based on their valence score rather than their arousal score. For instance, a recent study evaluated the validity of HRV for detecting differences in emotional responding to IAPS images and found that HRV was correlated with self-reported valence but only when participants viewed images with high arousal ratings (Choi, Kim, Kwon, Kim, Ryu, & Park, 2017).

Chronotype by Sleep Duration Interactions

Moderation analyses revealed that the association between chronotype and emotion regulation was dependent on sleep duration. Specifically, increases in HF-HRV from “look” to “reframe” trials were associated with longer sleep duration on non-free days but only among intermediate chronotypes. In extant literature, short habitual sleep duration has been associated with lower resting HF-HRV (Castro-Diehl et al., 2016). Sleep deprivation has also been shown to result in acute decreases in HRV (Zhong, Hilton, Gates, Jelic, Stern, Bartels, Demeersman, & Basner, 2005; Virtanen, Kelleinen, Urrila, & Lappanen, 2015; Tobaldini, Nobil, Strada, Casali, Braquhioli, & Montano, 2013). Autonomic reactivity to stress has also been shown to be sensitive to short sleep duration. Specifically, during lab stress tasks, Mezick and colleagues (2014) found that shorter sleep duration was associated with greater reductions in HF-HRV (Mezick, Matthews, Hall, Jennings, & Kamarck, 2014), while Franzen and colleagues (2011)

demonstrated that sleep deprivation resulted in increased blood pressure (Franzen, Gianaros, Marsland, Hall, Siegle, Dahl, & Buysse, 2011). Our finding that longer sleep duration was associated with increases in HF-HRV among intermediate chronotypes (i.e., non-evening chronotypes) is consistent with this literature.

Evening chronotypes demonstrated no association between sleep duration and change in HF-HRV during the negative emotion regulation task, indicating that longer sleep duration was not beneficial for this chronotype group. In part, this may have been because sleep duration on non-free days was longer for intermediate chronotypes compared with evening chronotypes (7.10 hours \pm 70 min and 6.15 hours \pm 82 min for intermediate and evening chronotypes, respectively; Table 2). Less than seven hours of sleep per night has been associated with lower resting HF-HRV (Castro-Diehl et al., 2016). Our results may suggest that less than seven hours of sleep is also associated with impaired modulation of HF-HRV through the cognitive reappraisal strategy “reframing”; however, sleep restriction studies are needed to test this proposition.

Chronotype by Time of Day Interactions

Time of day effects may have also influenced the pattern of results. In our sample as a whole, later testing sessions were associated with better regulation of negative emotions, defined by lengthening in PEPs. This time of day association was not moderated by chronotype. Reductions in SNS activation during negative emotion regulation may be due to circadian variations in positive affect. For instance, ambulatory studies have found that positive affect precedes changes in cardiovascular (Brosschot & Thayer, 2003) and autonomic functioning (Bacon et al., 2004). Positive affect has been shown to increase across the day, peaking in the early afternoon (Hasler et al., 2012; Miller et al., 2015). Therefore, circadian-dependent changes

in positive affect may have facilitated improved emotion regulation abilities specific to autonomic functioning.

In the current study, we tested emotion regulation within two hours of each participant's habitual wake time in order to avoid testing earlier chronotypes at their preferred time and later chronotypes at their unpreferred time, thereby artificially inflating chronotype group differences. However, as post-hoc analyses revealed, time of day was associated with differences in autonomic functioning. In the sample as a whole, later time of day was associated better negative emotion regulation as indicated by increases in PEP. Conversely, earlier time of day was associated with better negative emotion regulation as indicated by increases in HF-HRV, but only among evening chronotypes.

Only a small handful of stress reactivity studies have examined chronotype by time of day interactions with respect to autonomic functioning. These studies have systematically tested the synchrony effect (May & Hasher, 1998), that posits chronotypes perform better on tasks at their preferred time of day (Hahn et al., 2012; Lara, Madrid, & Correa, 2014; Tucker et al., 2012). Specifically, Roeser and colleagues (2012) examined responses to stress among 27 morning and 28 evening chronotypes during both morning and afternoon sessions. Evening chronotypes demonstrated lower HRV and both higher heart rate and systolic blood pressure during baseline and stress conditions (Roeser et al., 2012). Reactivity in systolic blood pressure and HRV were significantly higher in both chronotype groups during the afternoon testing session. Other studies have shown that chronotypes exhibited greater arousal during their preferred time of day (Nebel et al., 1996; Willis et al., 2005) while one other study indicated that arousal was greater when chronotypes were tested at their non-preferred time of day (Dunn & Taylor, 2014).

Our findings suggest that evening chronotypes have better parasympathetic control at earlier times (i.e., their non-preferred time). Because testing time was based on habitual wake-up times, this finding may suggest that evening chronotypes with earlier wake timing exhibit better emotion regulation, as indicated by parasympathetic control. Alternatively, this finding may suggest that evening chronotypes closer to the middle of the chronotype spectrum fair better than extreme evening chronotypes. Systematically testing emotion regulation at both preferred and non-preferred timing is necessary to fully understand time of day effects on emotion regulation across chronotypes.

Emotion Regulation Did Not Mediate Associations Between Eveningness and Alcohol Use Disorder Symptoms

In our sample, eveningness was associated with greater alcohol use disorder symptoms but chronotype was unrelated to changes in affective and autonomic variables during emotion regulation. Therefore, we were unable to test the model presented in Figure 1. Exploratory analyses also revealed that the mediation model was not moderated by sleep duration on non-free days or time of day.

To our knowledge, only three studies have examined emotion regulation as a mechanism linking substance use to an at-risk group. These studies have found mediation effects but only when emotion regulation was measured by a self-report questionnaire, such as the DERS, or affect during standardized emotion regulation tasks, such as the one used in the current study. Specifically, Khosravani and colleagues (2017) have shown that difficulty with emotion regulation, as measured by the DERS, mediated the association between positive/negative affect and alcohol cravings in a sample of alcoholic adults (Khosravani, Sharifi Bastan, Ghorbani, & Kamali, 2017). Radomski & Read (2016) have also shown that scores on the DERS mediated

associations between PTSD and alcohol use (Radomski & Read, 2016). Finally, positive affect during a “savor” condition of an emotion regulation task mediated the association between opioid misuse status and current cravings for opioids (Garland, Bryan, Nakamura, Froeliger, & Howard, 2017). Self-reported difficulties with emotion regulation or self-reported affect may be more likely to mediate associations between chronotype and alcohol use. However, in our sample, emotion regulation as measured by self-reported affect did not vary by chronotype and other self-report measures of emotion regulation were not administered.

Moderated Mediation Analyses

Moderated mediation revealed that the mediation model was not dependent on sleep duration on non-free days or time of day. Based on simulation studies conducted by Preacher, Rucker and Hayes (2007) a study with a sample size of 50-100 participants would only be sufficiently powered to find a conditional indirect effect if the effect was moderate or large. When conditional indirect effects are small, sample sizes of 200-500 participants are needed (Preacher, Rucker, & Hayes, 2007). Therefore, if the conditional effects of sleep duration and/or time of day exist, they may be small and the current study was underpowered to detect them.

Limitations

The current study had several limitations that are worth addressing. This study was limited to college students between the ages of 18-25, preventing generalizability beyond this demographic. While we maintain, that this is an important age-group for studying the associations between chronotype, emotion regulation and alcohol use, it is a unique population in several ways. While features of adolescence are still present at this age, college students have newly acquired autonomy and freedom to dictate their own bedtimes and, often, school schedules, which have a large influence on wake times. In addition, alcohol use and even misuse

become normalized within this age group and within college culture. Therefore, results should not be generalized beyond this demographic but may be used to inform future studies in older and younger, non-college based samples.

The chronotype distribution in our sample was also a limitation. Studies that compare morning and evening chronotype groups have used a variety of approaches to categorizing continuous measures such as the CSM and MEQ (e.g., a priori cutoffs, 10th and 90th percentiles, 20th and 80th percentiles, tertiles, and median splits). Studies using a priori cut-offs and studies that sample from the ends of a larger chronotype distribution often begin with very large sample sizes of around several hundred individuals. Given our practical limitations, we made efforts to recruit individuals who identified as “night owls” or “early birds” but studied all volunteers who met the inclusion criteria. Morning chronotypes were under-represented in our sample. The lack of group differences may have been due to our lack of morning chronotypes.

The current study was limited to measuring one week of sleep using a self-report diary rather than through objective or semi-objective means such as actigraphy. Hasler and colleagues have shown that physiological measures of circadian phase (i.e., DLMO) are more highly correlated with actigraphy-assessed sleep than diary-assessed sleep (Hasler, Bootzin, Cousins, Fridel, & Wenk, 2008). In order to more accurately characterize habitual sleep patterns in college students, future studies should strive to utilize more objective measures of sleep behavior.

Given the current study design, directionality of associations between chronotype and alcohol could not be inferred from the results of this study. It is possible that alcohol use contributed to later sleep timing by influencing sleep behavior or by delaying circadian biomarkers such as melatonin (Rupp, Acebo, & Carskadon, 2007). Future longitudinal and

ecological momentary assessment studies are needed to suss out whether adopting an evening chronotype precedes alcohol use or vice versa.

Finally, the current study was limited by the lack of effect emotion regulation had on autonomic physiology. Furthermore, negative and positive images also appeared to have no effect on HF-HRV or PEP. Studies using highly similar protocols have shown that autonomic activity is sensitive to both negatively and positively rated IAPS images (Garland et al., 2017). While the IAPS are highly validated, they have also been criticized for being somewhat outdated (Meiselman, 2016). More emotionally salient images that are consistent with modern standards may be necessary to evoke acute changes in PNS and SNS activation and fully assess emotion regulation across chronotype.

Strengths

Despite limitations, our study had several notable strengths. This is the first experimental study to examine emotion regulation in relation to chronotype. We measured affective and autonomic responses to negative, positive and neutral stimuli. Chronotype studies are most commonly conducted using batteries of self-report measures. The current study extends the literature by demonstrating that chronotypes do not differ in affective or autonomic measures when asked to regulate emotional responses to visual stimuli. However, by measuring habitual sleep patterns over the course of 7-days, we were able to show that sleep duration on non-free days moderated associations between chronotype and HRV-assessed negative emotion regulation, finding that longer sleep duration was protective for intermediate chronotypes.

While numerous studies have demonstrated an association between chronotype and alcohol use, few studies have tested moderators or mediators of this association. Exploratory analyses found that the association between chronotype and alcohol use was not moderated by

sex, sleep duration on non-free days, positive affect, conscientiousness, extroversion, or neuroticism. Because chronotype was unrelated to any measure of emotion regulation, it was determined that emotion regulation could not mediate the association between chronotype and alcohol use.

Implications and Future Directions

In our sample, evening chronotypes endorsed greater symptoms of alcohol use disorder. Our results have implications for public health given the developmental shift toward evening chronotype among adolescents and the persistence of evening chronotype into early adulthood. Future studies are needed to understand the circumstances surrounding sleep timing among college students who often have greater flexibility regarding their day-time social obligations. A longer and more detailed approach to observing sleep patterns and their circumstances in this population is needed.

Our results do not implicate emotion regulation in the causal pathway between chronotype and alcohol use, as chronotype did not predict affective or autonomic change during emotion regulation. Studies are needed to probe other potential mechanisms that might link evening chronotype to greater alcohol use. Un-related to alcohol consumption, our findings show that the association between chronotype and emotion regulation, as measured by change in HF-HRV, is moderated by sleep duration on non-free days and time of day. Among intermediate chronotypes, longer sleep duration was associated with greater increases in HF-HRV during cognitive reappraisal. Among evening chronotypes, earlier testing time was associated with greater increases in HF-HRV during cognitive reappraisal. These interactions were particular to down-regulating negative emotions. Further research is needed to understand time-of-day and

synchrony effects regarding chronotype, emotion regulation strategies and autonomic physiology.

Conclusions

The current study contributes to the literature by supporting the body of evidence showing that eveningness is associated with greater endorsement of alcohol use disorder symptoms. In addition, this study was the first to experimentally test both positive and negative emotion regulation among chronotypes. Our findings suggest chronotypes do not differ in affective or autonomic responses to emotion regulation strategies, though longer sleep duration may be protective for negative emotion regulation among intermediate chronotypes. Evening chronotypes who have an earlier habitual wake up time may also have improved parasympathetic control during negative emotion regulation, though systematic evaluation of this is needed. The current study has implications for public health given the predominance of an evening oriented culture in colleges and universities.

Table 1 Emotion regulation variable key

Type of Emotion Regulation	Outcome	Abbreviation	Calculation	Interpretation
Negative	Self-Report Affect	N-ER-SRA	Affect “Reframe” - Affect “Look”	Greater values = more positive affect when regulating negative emotion
	HF-HRV	N-ER-HRV	HRV “Reframe” - HRV “Look”	Greater values = increased HF-HRV when regulating negative emotion
	PEP	N-ER-PEP	PEP “Reframe” - PEP “Look”	Greater values = increased PEP when regulating negative emotion
Positive	Self-Report Affect	P-ER-SRA	Affect “Enhance” - Affect “Look”	Greater values = more positive affect when regulating positive emotion
	HF-HRV	P-ER-HRV	HRV “Enhance” - HRV “Look”	Greater values = increased HF-HRV when regulating positive emotion
	PEP	P-ER-PEP	PEP “Enhance” - PEP “Look”	Greater values = increased PEP when regulating positive emotion

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period; N = negative; P = positive; ER = emotion regulation

Table 2 Descriptive Characteristics

	Total N=81	Evening Chronotypes N=30	Intermediate Chronotypes N=51	Sig
Demographics				
Age	19.63 ± 1.17	19.65 ± 1.25	19.62 ± 1.12	.926
Sex, Female N(%)	55 (67.9%)	21 (67.7%)	34 (61.8%)	.981
Race White	56 (69.1%)	19 (61.3%)	37 (74.0%)	.682
Black	11 (13.6%)	5 (16.1%)	6 (12.0%)	
Asian	10 (12.3%)	5 (16.1%)	5 (10.0%)	
Other	4 (4.9%)	2 (6.5%)	2 (4.0%)	
Sleep				
SMP Free	6:04 am ± 95 min	7:02 am ± 83 min	5:29 am ± 85 min	<0.001
SMP NonFree	4:53 am ± 62 min	5:24 am ± 53 min	4:34 am ± 61 min	<0.001
SD Free	8.12 hrs ± 70 min	8.19 hrs ± 65 min	8.09 hrs ± 73 min	0.762
SD NonFree	6.74 hrs ± 79 min	6.15 hrs ± 82 min	7.10 hrs ± 70 min	0.002
Alcohol Consumption				
AUDIT	5.19 ± 3.83	6.35 ± 4.05	4.46 ± 3.54	0.029
Total Drinks 7-day	4.99 ± 6.04	5.57 ± 6.50	4.62 ± 5.76	0.505
Psychological				
IDS	13.49 ± 2.24	13.73 ± 2.41	13.34 ± 2.15	0.451
MDQ	0.72 ± 0.78	0.84 ± 0.82	0.64 ± 0.75	0.267
PTSD	0.20 ± 0.46	0.19 ± 0.48	0.20 ± 0.45	0.951
Affect				
Positive Affect	29.63 ± 8.06	27.60 ± 7.67	30.89 ± 8.11	0.074
Negative Affect	11.19 ± 5.09	11.39 ± 4.59	11.07 ± 5.42	0.785
Personality				
Openness	37.13 ± 6.23	37.61 ± 6.17	36.81 ± 6.32	0.581
Conscientiousness	32.51 ± 5.93	30.16 ± 5.11	34.00 ± 5.97	0.004
Extroversion	27.29 ± 6.33	28.26 ± 6.04	26.67 ± 6.49	0.278
Agreeableness	35.75 ± 5.36	34.42 ± 4.90	36.59 ± 5.52	0.077
Neuroticism	21.54 ± 5.88	22.23 ± 5.59	21.12 ± 6.07	0.419

N = sample size; SMP = sleep mid-point; Free = free days; Non-Free = non-free days; SD = sleep duration; AUDIT = alcohol use disorder identification test; IDS =

Inventory of Depressive Symptoms; MDQ = Mood Disorder Questionnaire; PTSD = post-traumatic stress disorder

Table 3 Manipulation Checks for Emotion Regulation Tasks

	Negative Images		Positive Images	
	“Look” versus “Reframe”		“Look” versus “Enhance”	
	t	sig	t	sig
SRA	-15.274	<0.001	-13.671	<0.001
HF-HRV	1.187	0.239	0.809	0.421
PEP	1.832	0.071	-0.875	0.385

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table 4 Chronotype predicting alcohol consumption

		AUDIT		Diary-Assessed Alcohol	
		F	sig	F	sig
Model 1	Chronotype	4.919	0.029	0.450	0.505
Model 2					
	Age	0.077	0.782	0.260	0.612
	Depression	1.273	0.263	0.193	0.661
	Chronotype	4.399	0.039	0.509	0.478

AUDIT = Alcohol Use Disorder Identification Test

Table 5 Chronotype negative emotion regulation

	Negative Emotion Regulation					
	SRA		HF-HRV		PEP	
	F	sig	F	sig	F	sig
Univariate	0.029	0.865	0.253	0.617	1.216	0.274
Adjusted*	0.016	0.899	0.191	0.663	1.823	0.181

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period; *Adjusted for age and depressive symptoms

Table 6 Chronotype positive emotion regulation

	Positive Emotion Regulation					
	Self-Report		HF-HRV		PEP	
	F	sig	F	sig	F	sig
Univariate	0.143	0.706	0.707	0.403	0.219	0.641
Adjusted*	0.135	0.715	0.743	0.392	0.159	0.692

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period; *Adjusted for age and depressive symptoms

Table 7 Regression coefficients for chronotype by effect modifier interactions predicting alcohol use

	AUDIT				Diary-Assessed Alcohol			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	β	sig	β	sig	β	sig	β	sig
Chronotype X Sex								
Chronotype X Sleep Duration Non-Free	-0.036	0.837	0.027	0.881	-0.047	0.795	-0.010	0.955
Chronotype X Positive Affect	-0.106	0.570	-0.224	0.243	-0.098	.609	-0.142	.480
Chronotype X Conscientiousness	0.053	0.791	0.028	0.890	-0.226	0.273	-0.232	0.266
Chronotype X Extroversion	0.108	0.560	0.110	0.555	0.147	0.447	0.125	0.529
Chronotype X Neuroticism	0.201	0.294	0.187	0.324	0.004	0.986	0.014	0.945

AUDIT = Alcohol Use Disorder Identification Test; *Adjusted for age and depressive symptoms

Table 8 Sex did not moderate associations between chronotype and emotion regulation

	Negative Emotion Regulation						Positive Emotion Regulation					
	SRA		HF-HRV		PEP		SRA		HF-HRV		PEP	
	F	sig	F	sig	F	sig	F	sig	F	sig	F	sig
Univariate	2.235	0.139	0.507	0.479	0.150	0.700	0.013	0.908	2.391	0.126	0.575	0.451
Adjusted*	1.080	0.303	0.029	0.865	0.358	0.551	0.400	0.672	2.759	0.101	0.689	0.409

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period; *Adjusted for age and depressive symptoms

Table 9 Interactions between sleep duration on non-free days and chronotype predicting emotion regulation

	Negative Emotion Regulation						Positive Emotion Regulation					
	SRA		HF-HRV		PEP		SRA		HF-HRV		PEP	
	β	sig	β	sig	β	sig	β	sig	β	sig	β	sig
Chronotype x Sleep Duration Non-Free	-0.272	0.126	0.367	0.039	0.215	0.240	-0.062	0.729	-0.023	0.899	-0.134	0.472
Adjusted for Age and Depressive Symptoms	-0.280	0.128	0.369	0.050	0.171	0.371	-0.077	0.676	0.015	0.938	-0.063	0.742

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table 10 Positive affect does not moderate associations between chronotype and emotion regulation

	Negative Emotion Regulation						Positive Emotion Regulation					
	SRA		HF-HRV		PEP		SRA		HF-HRV		PEP	
	β	sig	β	sig	β	sig	β	sig	β	sig	β	sig
Chronotype x Positive Affect	-0.109	0.571	0.001	0.998	0.179	0.382	-0.046	0.809	0.092	0.637	-0.217	0.281
Adjusted for Age and Depressive Symptoms	-0.143	0.477	0.030	0.882	0.268	0.203	-0.043	0.831	0.091	0.656	-0.253	0.228

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table 11 Conscientiousness does not moderate associations between chronotype and emotion regulation

	Negative Emotion Regulation						Positive Emotion Regulation					
	SRA		HF-HRV		PEP		SRA		HF-HRV		PEP	
	β	sig	β	sig	β	sig	β	sig	β	sig	β	sig
Chronotype x Conscientiousness	-0.038	0.856	-0.054	0.798	0.150	0.499	0.129	0.537	0.348	0.094	-0.121	0.589
Adjusted for Age and Depressive Symptoms	-0.042	0.843	-0.040	0.852	0.171	0.442	0.122	0.560	0.358	0.088	-0.129	0.570

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table 12 Extroversion does not moderate associations between chronotype and emotion regulation

	Negative Emotion Regulation						Positive Emotion Regulation					
	SRA		HF-HRV		PEP		SRA		HF-HRV		PEP	
	β	sig	β	sig	β	sig	β	sig	β	sig	β	sig
Chronotype x Extroversion	-0.123	0.530	0.250	0.207	0.181	0.360	-0.227	0.242	0.022	0.911	-0.050	0.804
Adjusted for Age and Depressive Symptoms	-0.121	0.547	0.254	0.214	0.194	0.333	-0.200	0.314	-0.001	0.995	-0.061	0.766

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table 13 Neuroticism does not moderate associations between chronotype and emotion regulation

	Negative Emotion Regulation						Positive Emotion Regulation					
	SRA		HF-HRV		PEP		SRA		HF-HRV		PEP	
	β	sig	β	sig	β	sig	β	sig	β	sig	β	sig
Chronotype x Neuroticism	-0.015	0.940	0.214	0.291	-0.282	0.151	0.099	0.608	0.012	0.953	0.126	0.529
Adjusted for Age and Depressive Symptoms	-0.020	0.919	0.218	0.289	-0.300	0.133	0.072	0.710	0.026	0.899	0.706	0.483

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table14 Interaction between time of day and chronotype predicting emotion regulation

	Negative Emotion Regulation						Positive Emotion Regulation					
	SRA		HF-HRV		PEP		SRA		HF-HRV		PEP	
	β	sig	β	sig	β	sig	β	sig	β	sig	β	sig
Chronotype x Time of day	0.057	0.744	0.347	0.047	0.194	0.261	0.190	0.277	0.027	0.878	-0.235	0.184
Adjusted for Age and Depressive Symptoms	0.061	0.730	0.351	0.048	0.189	0.271	0.175	0.325	0.034	0.848	-0.228	0.203

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Figure 1

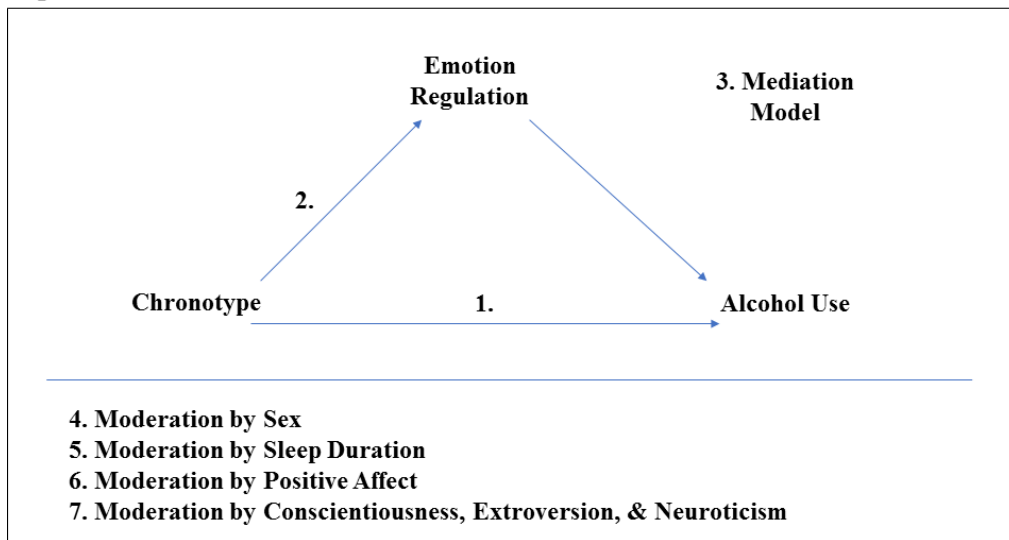
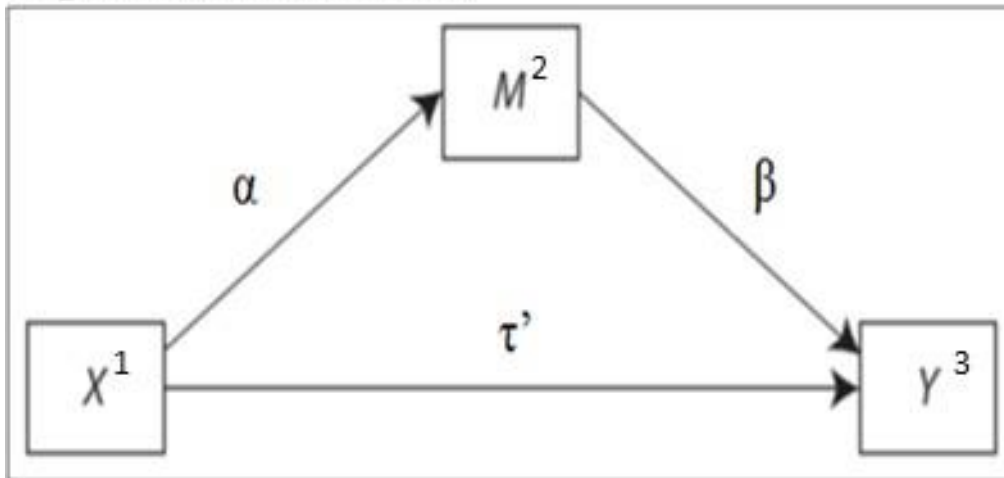
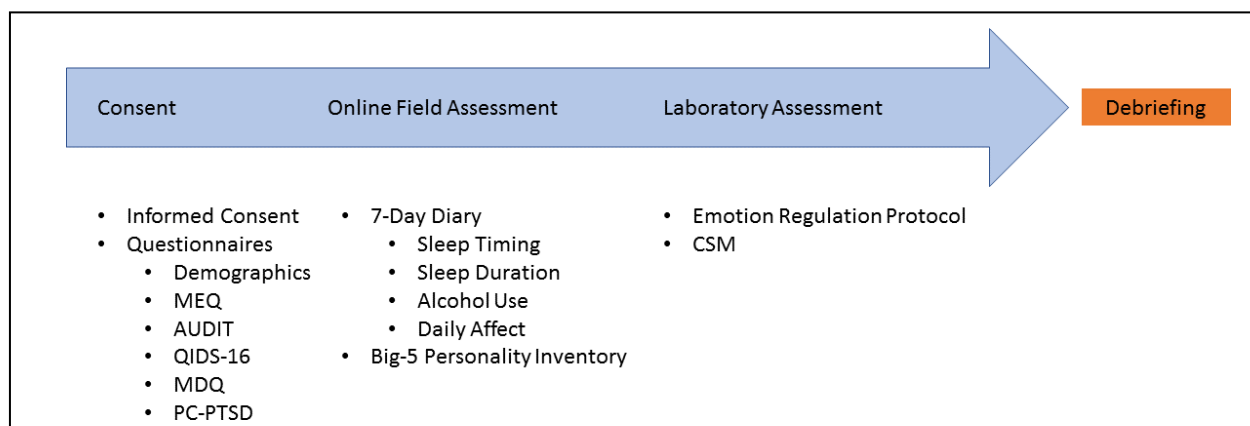


Figure 2 Mediation Model



1. Chronotype; 2. Emotion regulation; 3. Alcohol use.

Figure 3 Procedural Schematic



MEQ = Morningness-Eveningness Questionnaire; AUDIT = Alcohol Use Disorder Identification Test; QIDS-16 = Quick 16-Item Inventory of Depressive Symptoms; MDQ = Mood Disorder Questionnaire; PC-PTSD = Primary Care Post-Traumatic Stress Disorder Screen; CSM = Composite Scale of Morningness.

Figure 4

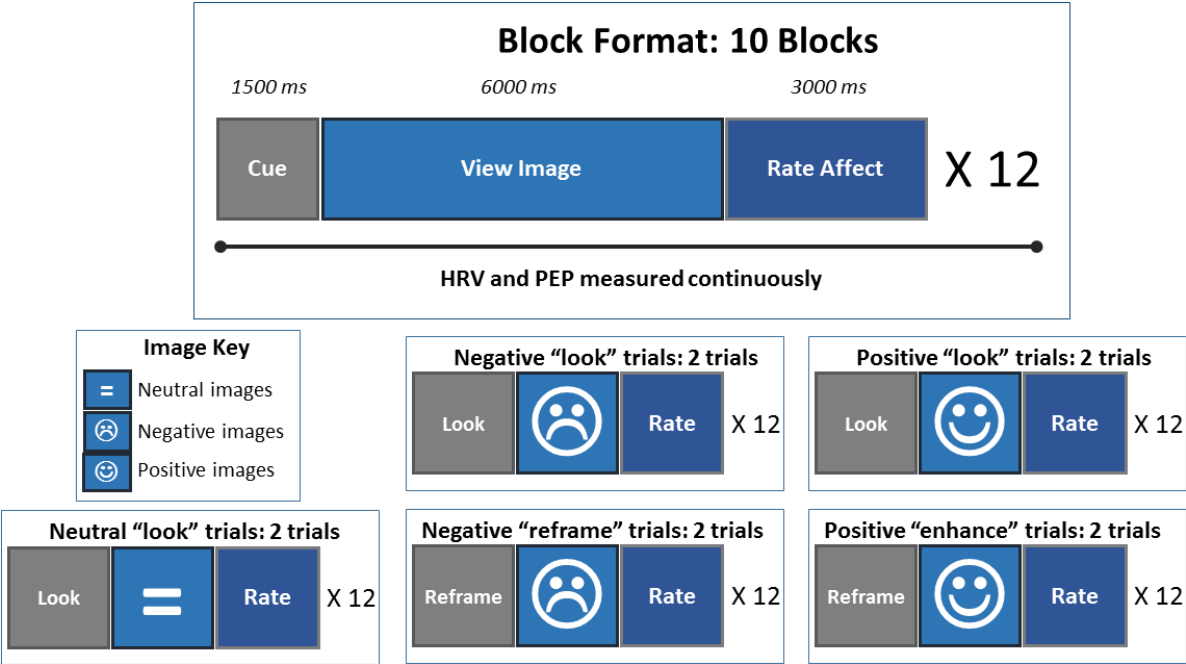


Figure 5

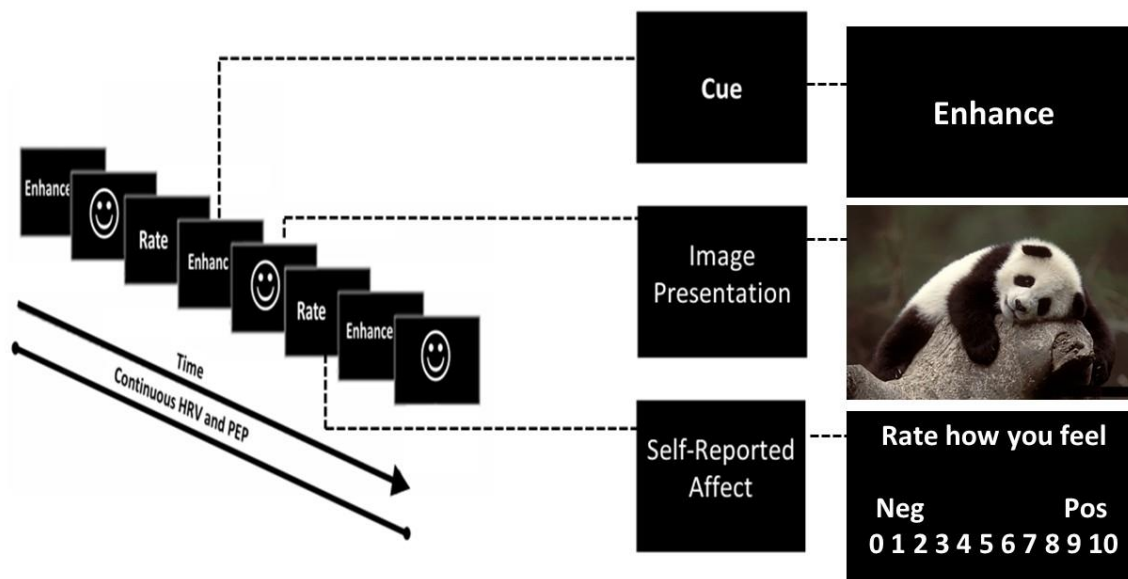


Figure 6 Moderated Mediation Model (Hayes, 2013)

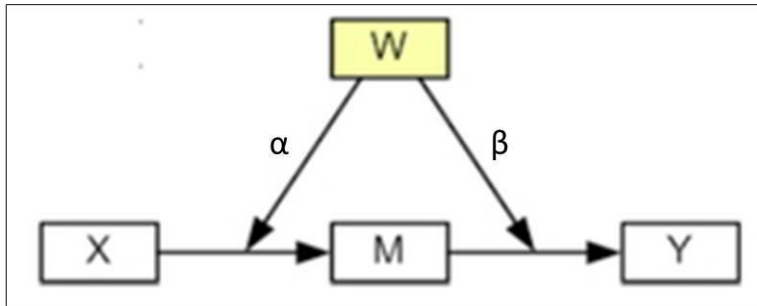


Figure 7

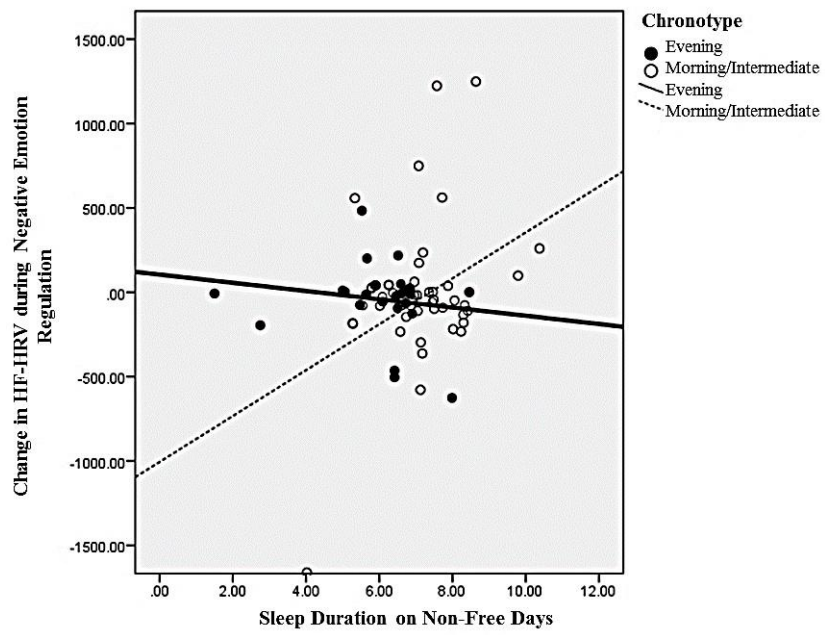
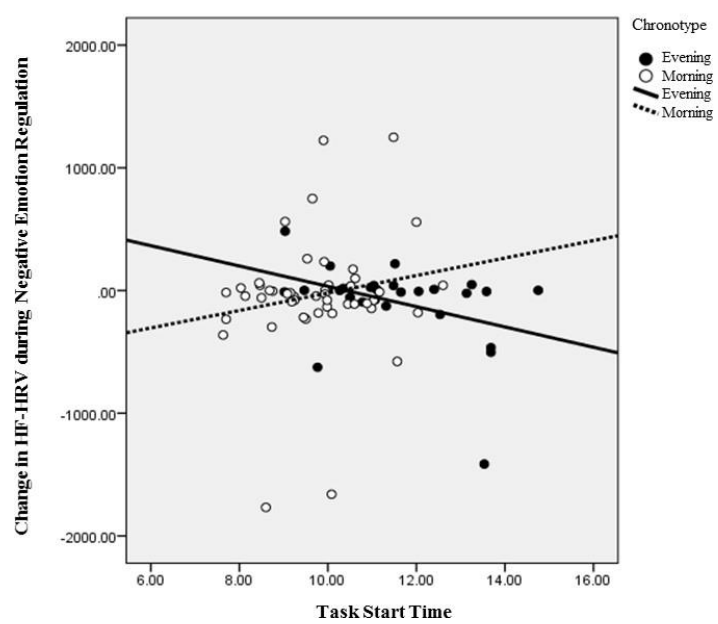


Figure 8



Appendix Tables

Table A1 Correlations between self-reported affect, HF-HRV and PEP during “look” trials

	SRA “Look” Trials			HF-HRV “Look” Trials			PEP “Look” Trials		
	Neutral	Negative	Positive	Neutral	Negative	Positive	Neutral	Negative	Positive
SRA Neutral	-	0.378***	-0.066	0.000	0.132	0.038	0.058	0.038	0.029
SRA Negative		-	-0.335**	0.161	0.263*	0.175	-0.079	-0.072	-0.103
SRA Positive			-	0.001	-0.024	0.029	-0.068	-0.102	-0.123
HF-HRV Neutral				-	0.850***	0.835***	-0.254*	-0.157	-0.209
HF-HRV Negative					-	0.770***	-0.168	-0.090	-0.162
HF-HRV Positive						-	-0.168	-0.088	-0.146
PEP Neutral							-	0.754***	0.847***
PEP Negative								-	0.932***
PEP Positive									-

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A2 Pearson correlations between SRA, HF-HRV and PEP during “reframe” trials

	SRA “Reframe” Trials Negative	HF-HRV “Reframe” Trials Negative	PEP “Reframe” Trials Negative
SRA Negative	-	0.259*	-0.245*
HF-HRV Negative		-	-0.058
PEP Negative			-

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period; * $p < 0.05$

Table A3 Pearson correlations between SRA, HF-HRV and PEP during “enhance” trials

	SRA “Enhance” Trials Positive	HF-HRV “Enhance” Trials Positive	PEP “Enhance” Trials Positive
Mood Positive	-	0.059	-0.114
HF-HRV Positive		-	-0.067
PEP Positive			-

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table A4 Pearson correlations between emotion regulation and alcohol measures

	AUDIT	Average Daily Alcohol
N-ER-SRA	-0.070	-0.058
N-ER-HRV	0.108	0.064
N-ER-PEP	0.130	0.160
P-ER-SRA	-0.069	-0.111
P-ER-HRV	0.103	0.086
P-ER-PEP	0.025	0.033

AUDIT = alcohol use disorder identification test; N = negative; P = positive; ER = emotion regulation; SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table A5 Sex differences in alcohol use

	Total	Males	Females	Sig
Average Daily Alcohol	0.71 ± 0.84	1.08 ± 0.20	0.68 ± 0.09	0.288
AUDIT Scores	5.41 ± 3.87	6.00 ± 4.02	5.10 ± 3.78	0.288

AUDIT = alcohol use identification test

Table A6 Sex differences in SRA, HF-HRV, and PEP during “look”, “reframe”, and “enhance” trials

Trial Type	Outcome	Image Type	Total	Males	Females	Sig
“Look” Trials	SRA	Neutral	522.64 ± 28.62	529.84 ± 37.94	519.30 ± 22.76	0.143
		Negative	330.46 ± 79.25	372.01 ± 90.08	311.22 ± 66.16	0.001
		Positive	648.65 ± 70.75	646.36 ± 82.09	649.70 ± 65.66	0.777
	HF-HRV	Neutral	699.55 ± 877.87	721.30 ± 860.58	689.48 ± 893.58	0.882
		Negative	667.27 ± 693.21	777.55 ± 731.07	616.22 ± 675.86	0.339
		Positive	637.68 ± 701.00	632.08 ± 579.91	640.28 ± 755.57	0.962
	PEP	Neutral	126.32 ± 12.15	128.27 ± 11.75	125.41 ± 12.34	0.335
		Negative	127.69 ± 16.31	127.43 ± 8.73	127.81 ± 18.94	0.923
		Positive	127.31 ± 15.97	127.71 ± 10.78	127.11 ± 18.00	0.878
“Reframe” Trials	SRA	Negative	485.41 ± 92.92	497.97 ± 108.60	479.60 ± 85.19	0.537
	HF-HRV	Negative	610.20 ± 627.19	698.48 ± 654.29	569.33 ± 616.18	0.398
	PEP	Negative	125.68 ± 13.13	127.34 ± 9.57	124.90 ± 14.52	0.448
“Enhance” Trials	SRA	Positive	728.37 ± 63.34	718.48 ± 72.11	732.95 ± 59.02	0.284
	HF-HRV	Positive	605.29 ± 699.47	650.62 ± 688.66	584.31 ± 709.84	0.698
	PEP	Positive	127.90 ± 16.72	126.46 ± 9.17	128.59 ± 19.33	0.603

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table A7 Sex differences in negative and positive emotion regulation

		Total	Males	Females	Sig
	SRA	154.95 ± 89.22	126.17 ± 102.12	168.28 ± 80.13	0.050
Negative Emotion Regulation	HF-HRV	-57.07 ± 427.47	-79.07 ± 482.83	-46.89 ± 403.76	0.758
	PEP	-2.01 ± 9.67	-0.09 ± 4.12	-2.91 ± 11.32	0.231
	SRA	79.72 ± 51.05	72.12 ± 40.50	83.24 ± 55.24	0.371
Positive Emotion Regulation	HF-HRV	-32.39 ± 355.92	18.53 ± 330.34	-55.96 ± 367.74	0.390
	PEP	0.60 ± 6.05	-1.26 ± 6.66	1.47 ± 5.60	0.062

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table A8 Associations between emotion regulation and alcohol
are not moderated by sex

	AUDIT		Average Daily Alcohol	
	β	sig	β	sig
Sex x N-ER-SRA	0.215	0.594	0.310	0.435
Sex x N-ER-HRV	0.354	0.367	-0.238	0.543
Sex x N-ER-PEP	-0.942	0.329	-0.312	0.745
Sex x P-ER-SRA	-0.783	0.153	-0.240	0.659
Sex x P-ER-HRV	-0.719	0.340	-0.532	0.247
Sex x P-ER-PEP	-0.479	0.232	-0.470	0.237

N = negative; P = positive; ER = emotion regulation; SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table A9 Pearson correlations between moderators and alcohol use

	Average Daily Alcohol	AUDIT
Sleep Duration on Non-Free Days	0.028	-0.005
Positive Affect	0.093	0.028
Conscientiousness	-0.060	-0.165
Extroversion	0.012	0.164
Neuroticism	0.036	-0.005

AUDIT = alcohol use identification test

Table A10 Pearson correlations between moderators and measures of negative and positive emotion regulation

	Negative Emotion Regulation			Positive Emotion Regulation		
	SRA	HF-HRV	PEP	SRA	HF-HRV	PEP
Sleep Duration NF	0.077	0.182	-0.011	-0.030	0.074	0.004
Positive Affect	0.134	0.178	0.050	-0.130	-0.055	-0.235*
Conscientiousness	-0.023	-0.038	0.044	0.080	-0.085	-0.089
Extroversion	0.047	0.000	0.100	0.110	-0.153	-0.037
Neuroticism	0.035	-0.016	-0.293*	-0.180	0.003	0.299**

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period; NF = non-free * $p < 0.05$, ** $p < 0.01$

Table A11 Associations between emotion regulation and alcohol are not moderated by sleep duration on non-free days

	AUDIT		Average Daily Alcohol	
	β	sig	β	sig
TST _{NF} x N-ER-SRA	-0.111	0.361	-0.111	0.362
TST _{NF} x N-ER-HRV	-0.020	0.864	0.086	0.474
TST _{NF} x N-ER-PEP	0.116	0.461	0.126	0.421
TST _{NF} x P-ER-SRA	0.049	0.701	0.037	0.770
TST _{NF} x P-ER-HRV	-0.069	0.579	0.021	0.868
TST _{NF} x P-ER-PEP	-0.228	0.067	-0.104	0.407

TST_{NF} = sleep duration on non-free days; N = negative; P = positive; ER = emotion regulation; SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table A12 Indirect effects of chronotype on AUDIT scores via emotion regulation are not moderated by sleep duration on non-free days

	Conditional Indirect Effects					
	1 SD below Mean SD_{NF}		Mean SD_{NF}		1 SD above Mean SD_{NF}	
	95% CI		95% CI		95% CI	
N-ER-SRA	-0.45	0.30	-0.14	0.53	-0.19	1.03
N-ER-HRV	-1.05	0.14	-0.29	0.36	-0.04	0.99
N-ER-PEP	-0.74	0.18	-0.38	0.18	-0.12	0.55
P-ER-SRA	-0.62	0.22	-0.36	0.18	-0.34	0.34
P-ER-HRV	-0.44	0.63	-0.27	0.57	-0.41	0.68
P-ER-PEP	-0.35	0.22	-0.17	0.36	-0.29	0.77

SD = standard deviation; SD_{NF} = Sleep duration on non-free days; CI = confidence interval; N = negative; P = positive; ER = emotion regulation; SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table A13 Associations between emotion regulation and alcohol
are not moderated by positive affect

	AUDIT		Average Daily Alcohol	
	β	sig	β	sig
PA x N-ER-SRA	0.101	0.390	-0.010	0.932
PA x N-ER-HRV	-0.071	0.555	-0.089	0.459
PA x N-ER-PEP	0.047	0.731	0.153	0.261
PA x P-ER-SRA	0.121	0.298	0.002	0.985
PA x P-ER-HRV	-0.019	0.872	0.100	0.388
PA x P-ER-PEP	0.116	0.331	0.228	0.054

PA = positive affect; N = negative; P = positive; ER = emotion regulation; SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table A14 Associations between emotion regulation and alcohol
are not moderated by conscientiousness

	AUDIT		Average Daily Alcohol	
	β	sig	β	sig
Con x N-ER-SRA	-0.050	0.666	0.086	0.464
Con x N-ER-HRV	-0.064	0.583	-0.003	0.978
Con x N-ER-PEP	-0.106	0.380	-0.032	0.789
Con x P-ER-SRA	-0.206	0.112	-0.060	0.647
Con x P-ER-HRV	-0.029	0.800	0.072	0.538
Con x P-ER-PEP	0.168	0.149	0.170	0.147

Con = conscientiousness; N = negative; P = positive; ER = emotion regulation; SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table A15 Associations between emotion regulation and alcohol
are not moderated by extroversion

	AUDIT		Average Daily Alcohol	
	β	sig	β	sig
Ext x N-ER-SRA	0.028	0.808	-0.035	0.767
Ext x N-ER-HRV	-0.060	0.611	-0.024	0.842
Ext x N-ER-PEP	-0.053	0.697	0.024	0.864
Ext x P-ER-SRA	0.105	0.381	-0.063	0.606
Ext x P-ER-HRV	0.043	0.716	-0.079	0.512
Ext x P-ER-PEP	0.138	0.230	0.085	0.466

Ext = extroversion; N = negative; P = positive; ER = emotion regulation; SRA = self-reported affect;

HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table A16 Associations between emotion regulation and alcohol
are not moderated by neuroticism

	AUDIT		Average Daily Alcohol	
	β	sig	β	sig
Ner x N-ER-SRA	0.046	0.703	0.031	0.794
Ner x N-ER-HRV	-0.082	0.533	-0.126	0.339
Ner x N-ER-PEP	-0.012	0.956	-0.014	0.948
Ner x P-ER-SRA	0.118	0.351	0.158	0.210
Ner x P-ER-HRV	-0.083	0.482	0.019	0.874
Ner x P-ER-PEP	-0.174	0.158	-0.214	0.082

Ner = neuroticism; N = negative; P = positive; ER = emotion regulation; SRA = self-reported affect;
HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table A17 Pearson correlations between time of day and emotion regulation						
	Negative Emotion Regulation			Positive Emotion Regulation		
	SRA	HF-HRV	PEP	SRA	HF-HRV	PEP
Time of Day	-0.072	-0.046	0.248*	-0.053	-0.169	-0.058
SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period; * p < 0.05						

Table A18 Indirect effects of chronotype on AUDIT scores via emotion regulation are not moderated by time of day

	Conditional Indirect Effects					
	1 SD below Mean ToD		Mean ToD		1 SD above Mean ToD	
	95% CI		95% CI		95% CI	
N-ER-SRA	-0.35	0.85	-0.17	0.47	-0.34	0.43
N-ER-HRV	-0.73	0.10	-0.29	0.35	-0.09	0.93
N-ER-PEP	-0.46	0.83	-0.26	0.03	-0.31	0.41
P-ER-SRA	-0.44	0.42	-0.26	0.16	-0.50	0.29
P-ER-HRV	-0.89	0.58	-0.42	0.44	-0.43	0.82
P-ER-PEP	-0.17	0.69	-0.20	0.42	-0.60	0.42

SD = standard deviation; ToD = time of day; CI = confidence interval; N = negative; P = positive; ER = emotion regulation; SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Table A19 Difference in affective and autonomic measures between neutral and emotional “look” trials

	Neutral vs Negative Images		Neutral vs Positive Images	
	t	sig	t	sig
SRA	23.283	< 0.001	-14.351	< 0.001
HF-HRV	0.616	0.540	1.137	0.259
PEP	-1.126	0.264	-1.009	0.316

SRA = self-reported affect; HF-HRV = high frequency heart rate variability; PEP = pre-ejection period

Reference List

- Adan, A. (1994). Chronotype and personality factors in the daily consumption of alcohol and psychostimulants. *Addiction*, 89(4), 455-462. Retrieved from PM:8025504
- Antypa, N., Vogelzangs, N., Meesters, Y., Schoevers, R., & Penninx, B. W. (2016). Chronotype associations with depression and anxiety disorders in a large cohort study. *Depress. Anxiety*, 33(1), 75-83. doi:10.1002/da.22422 [doi]. Retrieved from PM:26367018
- Aurora, P., & Klanecky, A. K. (2016). Drinking motives mediate emotion regulation difficulties and problem drinking in college students. *American Journal of Drug and Alcohol Abuse*, 42(3), 341- 350. doi:10.3109/00952990.2015.1133633 [doi]. Retrieved from PM:26905517
- Azizi, A., Borjali, A., & Golzari, M. (2010). The effectiveness of emotion regulation training and cognitive therapy on the emotional and addictional problems of substance abusers. 5(2): 60-65.
- Bacon, S.L., Watkins, L.L., Babyak, M., Sherwood, A., Hayano, J., Hinderliter, A.L., Waugh, R., & Blumenthal, J.A. (2004). Effects of daily stress on autonomic cardiac control in patients with coronary artery disease. *Am J Cardiol*. 93(10): 1292-4. DOI: 10.1016/j.amjcard.2004.02.018
- Baron, R.M. & Kenny, D.A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of*

- Personality and Social Psychology, 51(6): 1173-82.
- Baum, K. T., Desai, A., Field, J., Miller, L. E., Rausch, J., & Beebe, D. W. (2014). Sleep restriction worsens mood and emotion regulation in adolescents. *Journal of Child Psychology and Psychiatry*, 55(2), 180-190. doi:10.1111/jcpp.12125 [doi]. Retrieved from PM:24889207
- Beauchaine, T. (2001). Vagal tone, development, and Gray's motivational theory: toward an integrated model of autonomic nervous system functioning in psychopathology. *Development and Psychopathology*, 13(2), 183-214. Retrieved from PM:11393643
- Beauchaine, T.P., Gatzke-Kopp, L., & Mead, H.K. (2007). Polyvagal theory and developmental psychopathology: Emotion dysregulation and conduct problems from preschool to adolescence. *Biol Psychol.* 74(2): 174-84. doi: 10.1016/j.biopsycho.2005.08.008
- Berdynaj, D., Boudissa, S. N., Grieg, M. S., Hope, C., Mahamed, S. H., & Norbury, R. (2016). Effect of chronotype on emotional processing and risk taking. *Chronobiol.Int.*, 33(4), 406-418. doi:10.3109/07420528.2016.1146739 [doi]. Retrieved from PM:27030174
- Berking, M., Wupperman, P., Reichardt, A., Pejic, T., Dippel, A., & Znoj, H. (2008). Emotion-regulation skills as a treatment target in psychotherapy. *Behav.Res.Ther.*, 46(11), 1230-1237. doi:S0005-7967(08)00171-X [pii];10.1016/j.brat.2008.08.005 [doi]. Retrieved from PM:18835479
- Berna, G., Ott, L., & Nandrino, J. L. (2014). Effects of emotion regulation difficulties on the tonic and phasic cardiac autonomic response. *PLoS.One.*, 9(7), e102971. doi:10.1371/journal.pone.0102971 [doi];PONE-D-13-43403 [pii]. Retrieved from PM:25054913
- Berntson, G.G., Lozano, D.L., Chen, Y.J., & Cacioppo, J.T. (2004). Where to Q

- in PEP. *Psychophysiology*. 41(2): 333-7.
- Beseler, C. L., Aharonovich, E., & Hasin, D. S. (2011). The enduring influence of drinking motives on alcohol consumption after fateful trauma. *Alcohol Clin.Exp.Res.*, 35(5), 1004-1010. doi:10.1111/j.1530-0277.2010.01431.x [doi]. Retrieved from PM:21314697
- Biss, R. K., & Hasher, L. (2012). Happy as a lark: morning-type younger and older adults are higher in positive affect. *Emotion.*, 12(3), 437-441. doi:2012-02789-001 [pii];10.1037/a0027071 [doi]. Retrieved from PM:22309732
- Blevins, C.E., Abrantes, A.M., & Stephens, R.S. (2016). Motivational pathways from antecedents of alcohol use to consequences: A structural model of using alcohol to cope with negative affect. *Am J Drug Alcohol Abuse*, 42(4): 395-403. doi: 10.3109/00952990.2016.1141915.
- Bold, K.W., Fucito, L.M., Corbin, W.R., DeMartini, K.S., Leeman, R.F., Kranzler, H.R., & O'Malley, S.S. (2016). Daily relations among affect, urge, targeted naltrexone, and alcohol use in young adults. *Exp Clin Psychopharmacol*. 24(5): 367-75.
- Brosschot, J.F. & Thayer, J.F. (2003). Heart rate response is longer after negative emotions than after positive emotions. *Int J Psychophysiol*. 50(3): 181-7.
- Cai, A., Lou, Y., Long, Q., & Yuan, J. (2016). The sex differences in regulating unpleasant emotion by expressive suppression: Extraversion matters. *Front Psychol*. 7: 1011. doi: 10.3389/fpsyg.2016.01011
- Carrier, J., Monk, T. H., Buysse, D. J., & Kupfer, D. J. (1997). Sleep and morningness-eveningness in the "middle" years of life (20-59y). *J.Sleep Res.*, 6, 230-237.
- Carskadon, M. A., Acebo, C., & Jenni, O. G. (2004). Regulation of adolescent sleep: implications for behavior. *Ann N Y Acad Sci*, 1021, 276-291. Retrieved from

PM:15251897

Carskadon, M. A., Bearpark, H. M., Sharkey, K. M., Millman, R. P., Rosenberg, C., Cavallo, A. et al. (1997). Effects of menopause and nasal occlusion on breathing during sleep.

American Journal of Respiratory and Critical Care Medicine, 155(1), 205-210.

Retrieved from PM:0009001313

Carstensen, L. L., & Lockenhoff, C. E. (2003). Aging, emotion, and evolution: the bigger picture.

Ann.N.Y.Acad.Sci., 1000, 152-179. Retrieved from PM:14766629

Castro-Diehl, C., Diez Roux, A.V., Redline, S., Seeman, T., McKinley, P., Sloan, R., & Shea, S.

(2016). Sleep duration and quality in relation to autonomic nervous system measures: The Multi-Ethnic Study of Atherosclerosis (MESA). *Sleep*. 39(11): 1927-40.

DOI:[10.5665/sleep.6218](https://doi.org/10.5665/sleep.6218)

Cavallera, G. M., Gatto, M., & Boari, G. (2014). Personality, cognitive styles and

Morningness- Eveningness disposition in a sample of Yoga trainees. *Med.Sci.Monit.*,

20, 238-246. doi:889030 [pii];10.12659/MSM.889030 [doi]. Retrieved from

PM:24531385

Chapman, B.P., Weiss, A., Barrett, P., & Duberstein, P. (2013). Hierarchical structure of the

Eysenck Personality Inventory in a large population sample: Goldberg's Trait-Tier

Mapping Procedure. *Pers Individ Dif*. 54(4): 479-84. DOI:

10.1016/j.paid.2012.09.024

Chaput, J.P., McNeil, J., Despres, J.P., Bouchard, C., & Tremblay, A. (2012). Short sleep

duration is associated with greater alcohol consumption in adults. *Appetite*. 59(3):

650-5. doi: 10.1016/j.appet.2012.07.012.

Choi, K., Kim, J., Kwon, O.S., Kim, M.J., Ryu, Y.H., & Park, J. (2017). Is heart rate variability

(HRV) an adequate tool for evaluating human emotions? - A focus on the use of the

International Affective Picture System (IAPS). *Psychiatry Res.*251: 196.

DOI:[10.1016/j.psychres.2017.02.025](https://doi.org/10.1016/j.psychres.2017.02.025)

Christou-Champi, S., Farrow, T. F., & Webb, T. L. (2015). Automatic control of negative emotions: evidence that structured practice increases the efficiency of emotion regulation. *Cogn Emot.*, 29(2), 319-331. doi:10.1080/02699931.2014.901213 [doi].

Retrieved from PM:24678930

Cisler, J.M., & Olatunji, B.O. (2012). Emotion regulation and anxiety disorders. *Curr Psychiatry Rep*, 14(3), 182-187.

Clark, C.A., Skowron, E.A., Giuliano, R.J., & Fisher, P.A. (2016). Intersections between cardiac physiology, emotion regulation and interpersonal warmth in preschoolers: Implications for drug abuse prevention from translational neuroscience. *Drug Alcohol Depend.* 163 Suppl 1: S60-9. doi: 10.1016/j.drugalcdep.2016.01.033.

Clark, D. B., Pollock, N., Bukstein, O. G., Mezzich, A. C., Bromberger, J. T., & Donovan, J. E. (1997). Gender and comorbid psychopathology in adolescents with alcohol dependence. *J.Am.Acad.Child Adolesc.Psychiatry*, 36(9), 1195-1203. doi:S0890-8567(09)62644-7 [pii];10.1097/00004583-199709000-00011 [doi]. Retrieved from PM:9291720

Collado-Rodriguez, A., MacPherson, L., Kurdziel, G., Rosenberg, L. A., & Lejuez, C. W. (2014). The Relationship between Puberty and Risk Taking in the Real World and in the Laboratory. *Pers.Individ.Dif.*, 68, 143-148. doi:10.1016/j.paid.2014.04.019 [doi]. Retrieved from PM:24999291

Cooper, M. L., Frone, M. R., Russell, M., & Mudar, P. (1995). Drinking to regulate positive and negative emotions: a motivational model of alcohol use. *J.Pers.Soc.Psychol.*, 69(5), 990-1005. Retrieved from PM:7473043

Crowell, S.E., Beauchaine, T.P., McCauley, E., Smith, C.J., Stevens, A.L., & Sylvers, P., (2005).

- Psychological, autonomic, and serotnergic correlates of parasuicide among adolescent girls. *Dev Psychopathol.* 17(4): 1105-27.
- Crowley, S. J., Acebo, C., & Carskadon, M. A. (2012). Human puberty: salivary melatonin profiles in constant conditions. *Dev.Psychobiol.*, 54(4), 468-473.
doi:10.1002/dev.20605 [doi]. Retrieved from PM:21953482
- Crowley, S. J., Van, R. E., LeBourgeois, M. K., Acebo, C., Tarokh, L., Seifer, R. et al. (2014). A longitudinal assessment of sleep timing, circadian phase, and phase angle of entrainment across human adolescence. *PLoS.One.*, 9(11), e112199.
doi:10.1371/journal.pone.0112199 [doi];PONE- D-14-30929 [pii]. Retrieved from PM:25380248
- Culnan, E., Kloss, J. D., & Grandner, M. (2013). A prospective study of weight gain associated with chronotype among college freshmen. *Chronobiol.Int.*, 30(5), 682-690. doi:10.3109/07420528.2013.782311 [doi]. Retrieved from PM:23688114
- Curtin, J. J., Lang, A. R., Patrick, C. J., & Stritzke, W. G. (1998). Alcohol and fear-potentiated startle: the role of competing cognitive demands in the stress-reducing effects of intoxication. *J.Abnorm.Psychol.*, 107(4), 547-557. Retrieved from PM:9830242
- Dagys, N., McGlinchey, E. L., Talbot, L. S., Kaplan, K. A., Dahl, R. E., & Harvey, A. G. (2012). Double trouble? The effects of sleep deprivation and chronotype on adolescent affect. *Journal of Child Psychology and Psychiatry*, 53(6), 660-667. doi:10.1111/j.1469-7610.2011.02502.x [doi]. Retrieved from PM:22188424
- De Witte, N. A., Sutterlin, S., Braet, C., & Mueller, S. C. (2016). Getting to the Heart of Emotion Regulation in Youth: The Role of Interoceptive Sensitivity, Heart Rate Variability, and Parental Psychopathology. *PLoS.One.*, 11(10), e0164615.
doi:10.1371/journal.pone.0164615 [doi];PONE- D-16-05827 [pii]. Retrieved from

PM:27741261

Del Rio-Bermudez, C., Diaz-Piedra, C., Catena, A., Buena-Casal, G., & Di Stasi, L. L. (2014).

Chronotype-dependent circadian rhythmicity of driving safety. *Chronobiol.Int.*, 31(4), 532-541. doi:10.3109/07420528.2013.876427 [doi]. Retrieved from PM:24400856

Derefinko, K.J., Eisenlohr-Moul, T.A., Peters, J.R., Roberts, W., Walsh, E.C., Milich, R., &

Lynam, D.R. (2016). Physiological response to reward and extinction predicts alcohol, marijuana, and cigarette use two years later. *Drug Alcohol Depend*, 163 Suppl 1:S29-S36. doi: 10.1016/j.drugalcdep.2016.01.034.

Di Simplicio, M., Costoloni, G., Western, D., Hanson, B., Taggart, P., & Harmer, C. J. (2012).

Decreased heart rate variability during emotion regulation in subjects at risk for psychopathology. *Psychological Medicine*, 42(8), 1775-1783. doi:S0033291711002479 [pii];10.1017/S0033291711002479 [doi]. Retrieved from PM:22067596

Diaz-Morales, J. F., Escribano, C., Jankowski, K. S., Vollmer, C., & Randler, C. (2014).

Evening adolescents: The role of family relationships and pubertal development. *Journal of Adolescence*, 37(4), 425-432.

Dragan, M. (2015). Difficulties in emotion regulation and problem drinking in young

women: The mediating effect of metacognitions about alcohol use. *Addict Behav*, 48, 30-35.

Dunn, B.D. (2017). Opportunities and challenges for the emerging field of positive emotion

regulation: A commentary on the special edition on positive emotions and cognitions in clinical psychology. *Cognit Ther Res*. 41(3): 469-78. doi: 10.1007/s10608-017-9831-3

Dunn, J. S., & Taylor, C. E. (2014). Cardiovascular reactivity to stressors: effect of time of day?

Chronobiol.Int., 31(2), 166-174. doi:10.3109/07420528.2013.833517 [doi].

Retrieved from PM:24144244

- Dvorak, R. D., Sargent, E. M., Kilwein, T. M., Stevenson, B. L., Kuvaas, N. J., & Williams, T. J. (2014). Alcohol use and alcohol-related consequences: associations with emotion regulation difficulties. *American Journal of Drug and Alcohol Abuse*, 40(2), 125-130. doi:10.3109/00952990.2013.877920 [doi]. Retrieved from PM:24588419
- Efron, B. & Tibshirani, R.J. (1993). An introduction to the bootstrap. CRC press, 1994. European Task Force Society of Cardiology & the North American Society of Pacing & Electrophysiology. (1996). Heart rate variability-standards of measurement, physiological interpretation, and clinical use. *Circulation*, 93(5), 1043-1065.
- Fernandez-Mendoza, J., Calhoun, S., Bixler, E. O., Pejovic, S., Karataraki, M., Liao, D. et al. (2010). Insomnia with objective short sleep duration is associated with deficits in neuropsychological performance: a general population study. *Sleep*, 33(4), 459-465. Retrieved from PM:20394314
- Francis, H. M., Penglis, K. M., & McDonald, S. (2016). Manipulation of heart rate variability can modify response to anger-inducing stimuli. *Soc.Neurosci.*, 11(5), 545-552. doi:10.1080/17470919.2015.1115777 [doi]. Retrieved from PM:26592092
- Franzen, P.L., Gianaros, P.J., Marsland, A.L., Hall, M.H., Siegle, G.J., Dahl, R.E., & Buysse, D.J. (2011). Cardiovascular reactivity to acute psychological stress following sleep deprivation. *Psychosom Med.* 73(8): 679-82. doi: 10.1097/PSY.0b013e31822ff440
- Fritz, M. S., & MacKinnon, D. P. (2007). Required sample size to detect the mediated effect. *Psychol.Sci.*, 18(3), 233-239. doi:PSCI1882 [pii];10.1111/j.1467-9280.2007.01882.x [doi]. Retrieved from PM:17444920
- Fussner, L.M., Luebke, A.M., & Bell, D.J. (2015). Dynamics of positive emotion regulation: Associations with youth depressive symptoms. *J Abnorm Child Psychol.* 43(3): 475-88. doi: 10.1007/s10802-014-9916-3

- Fustos, J., Gramann, K., Herbert, B.M., & Pollatos, O. (2013). On the embodiment of emotion regulation: interoceptive awareness facilitates reappraisal. *Soc Cogn Affect Neurosci.* 8(8): 911-7. doi: 10.1093/scan/nss089
- Gaina, A., Sekine, M., Kanayama, H., Takashi, Y., Hu, L., Sengoku, K. et al. (2006). Morning-evening preference: sleep pattern spectrum and lifestyle habits among Japanese junior high school pupils. *Chronobiol.Int.*, 23(3), 607-621. doi:NV25T078U464081Q [pii];10.1080/07420520600650646
- Gardener, E. K., Carr, A. R., Macgregor, A., & Felmingham, K. L. (2013). Sex differences and emotion regulation: an event-related potential study. *PLoS.One.*, 8(10), e73475. doi:10.1371/journal.pone.0073475 [doi];PONE-D-13-13495 [pii]. Retrieved from PM:24204562
- Garland, E.L., Bryan, C.J., Nakamura, Y., Froeliger, B., & Howard, M.O. (2017). Deficits in autonomic indices of emotion regulation and reward processing associated with prescription opioid use and misuse. *Psychopharmacology.* 234(4): 621-9. doi: 10.1007/s00213-016-4494-4
- Gau, S. S., Shang, C. Y., Merikangas, K. R., Chiu, Y. N., Soong, W. T., & Cheng, A. T. (2007). Association between morningness-eveningness and behavioral/emotional problems among adolescents. *J.Biol.Rhythms*, 22(3), 268-274. doi:22/3/268 [pii];10.1177/0748730406298447 [doi]. Retrieved from PM:17517916
- Gau, S. S., Soong, W. T., & Merikangas, K. R. (2004). Correlates of sleep-wake patterns among children and young adolescents in Taiwan. *Sleep*, 27(3), 512-519. Retrieved from PM:15164908
- Giannotti, F., Cortesi, F., Sebastiani, T., & Ottaviano, S. (2002). Circadian preference, sleep and daytime behaviour in adolescence. *Journal of Sleep Research*, 11(3), 191-199. Retrieved

from PM:12220314

Giglio, L. M., Magalhaes, P. V., Andersen, M. L., Walz, J. C., Jakobson, L., & Kapczinski, F.

(2010). Circadian preference in bipolar disorder. *Sleep Breath.*, 14(2), 153-155.

doi:10.1007/s11325-009-0301-3 [doi]. Retrieved from PM:19774406

Gilpin, N. W., & Koob, G. F. (2008). Neurobiology of alcohol dependence: focus on

motivational mechanisms. *Alcohol Res.Health*, 31(3), 185-195. Retrieved from

PM:19881886

Giuliani, N.R., McRae, K., & Gross, J.J. (2008). The up- and down-regulation of

amusement: Experiential, behavioral and autonomic consequences. *Emotion*,

8(5), 714-719.

Gobin, C. M., Banks, J. B., Fins, A. I., & Tartar, J. L. (2015). Poor sleep quality is associated

with a negative cognitive bias and decreased sustained attention. *Journal of Sleep*

Research, 24(5), 535- 542. doi:10.1111/jsr.12302 [doi]. Retrieved from PM:25913483

Gottfredson, N. C., & Hussong, A. M. (2013). Drinking to dampen affect variability:

findings from a college student sample. *J.Stud.Alcohol Drugs*, 74(4), 576-583.

Retrieved from PM:23739021

Gratz, K.L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and

dysregulation: Development, factor structure, and initial validation of the difficulties in

emotion regulation scale. *Journal of Psychopathology & Behavioral Assessment*, 26(1),

41-54.

Grayson, C. E., & Nolen-Hoeksema, S. (2005). Motives to drink as mediators between

childhood sexual assault and alcohol problems in adult women. *J.Trauma Stress.*, 18(2),

137-145. doi:10.1002/jts.20021 [doi]. Retrieved from PM:16281206

Grekin, E. R., Sher, K. J., & Krull, J. L. (2007). College spring break and alcohol use: effects of

- spring break activity. *J.Stud.Alcohol Drugs*, 68(5), 681-688. Retrieved from PM:17690801
- Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology*, 2(3), 271-299.
- Gross, J. J. (2002). Emotion regulation: affective, cognitive, and social consequences. *Psychophysiology*, 39(3), 281-291. doi:10.1017.S0048577201393198 [doi];S0048577201393198 [pii]. Retrieved from PM:12212647
- Gross, J. J., & Levenson, R. W. (1997). Hiding feelings: the acute effects of inhibiting negative and positive emotion. *Journal of Abnormal Psychology*, 106(1), 95-103. Retrieved from PM:9103721
- Gross, J.J., & Thompson, R.A. Emotion Regulation: Conceptual foundations. In: Gross, J.J. editor. Handbook of emotion regulation. New York, NY: Guilford; 2007. pp. 3-24.
- Gruber, R., & Cassoff, J. (2014). The interplay between sleep and emotion regulation: conceptual framework empirical evidence and future directions. *Curr.Psychiatry Rep.*, 16(11), 500. doi:10.1007/s11920-014-0500-x [doi]. Retrieved from PM:25200984
- Hahn, C., Cowell, J. M., Wiprzycka, U. J., Goldstein, D., Ralph, M., Hasher, L. et al. (2012). Circadian rhythms in executive function during the transition to adolescence: the effect of synchrony between chronotype and time of day. *Dev.Sci.*, 15(3), 408-416. doi:10.1111/j.1467- 7687.2012.01137.x [doi]. Retrieved from PM:22490180
- Hakkarainen, R., Johansson, C., Kieseppa, T., Partonen, T., Koskenvuo, M., Kaprio, J. et al. (2003). Seasonal changes, sleep length and circadian preference among twins with bipolar disorder. *BMC Psychiatry*, 3, 6. Retrieved from PM:12795811
- Haraszti, R.A., Purebl, G., Salavecz, G., Poole, L., Dockray, S., & Steptoe, A. (2014).

- Morningness- eveningness interferes with perceived health, physical activity, diet and stress levels in workin women: A cross-sectional study. *Chronobiol Int.* 31(7): 829-37. doi: 10.3109/07420528.2014.911188
- Harvey, A. G., Murray, G., Chandler, R. A., & Soehner, A. (2011). Sleep disturbance as transdiagnostic: consideration of neurobiological mechanisms. *Clin.Psychol.Rev.*, 31(2), 225-235. doi:S0272- 7358(10)00066-8 [pii];10.1016/j.cpr.2010.04.003 [doi]. Retrieved from PM:20471738
- Hasler, B.P., Bootzin, R.R., Cousins, J.C., Fridel, K., & Wenk, G.L. (2008). Circadian phase in sleep- disturbed adolescents with a history of substance abuse: A pilot study. *Behav Sleep Med.* 6(1): 55-73. doi: 10.1080/15402000701796049.
- Hasler, B. P., Nofzinger, E. A., Germain, A., Kupfer, D. J., Krafty, R. T., Rothenberger, J. A. et al. (2012). Chronotype and diurnal patterns of positive affect and affective neural circuitry in primary insomnia. *Journal of Sleep Research*, 21(5), 515-526.
- Hasler, B. P., Sitnick, S. L., Shaw, D. S., & Forbes, E. E. (2013). An altered neural response to reward may contribute to alcohol problems among late adolescents with an evening chronotype. *Psychiatry Res.*, 214(3), 357-364. doi:S0925-4927(13)00218-7 [pii];10.1016/j.psychresns.2013.08.005 [doi]. Retrieved from PM:24144507
- Hayano, J., Sakakibara, Y., Yamada, A., Yamada, M., Mukai, S., Fujnami, T., Yokoyama, K., Watanabe, Y., & Takata, K. (1991). Accuracy of assessment of cardiac vagal tone by heart rate variability in normal subjects. *Am J Cardiol.* 67(2): 199-204.
- Hayes, A.F. (2013). Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach. New York, NY: Guilford Press.
- Hechtman, L. A., Raila, H., Chiao, J. Y., & Gruber, J. (2013). Positive Emotion Regulation and Psychopathology: A Transdiagnostic Cultural Neuroscience Approach.

- J.Exp.Psychopathol.*, 4(5), 502-528. doi:10.5127/jep.030412 [doi]. Retrieved from PM:24812583
- Heller, A.S., Johnstone, T., Shackman, A.J., Light, S.N., Peterson, M.J., Kolden, G.G., Kalin, N.H., & Davidson, R.J. (2009). Reduced capacity to sustain positive emotion in major depression reflects diminished maintenance of fronto-striatal brain activation. *Proc Natl Acad Sci U S A*. 106(52): 22445-50. doi: 10.1073/pnas.0910651106.
- Heller, A.S., Johnstone, T., Peterson, M.J., Kolden, G.G., Kalin, N.H., & Davidson, R.J. (2013). Increased prefrontal cortex activity during negative emotion regulation as a predictor of depression symptom severity trajectory over 6 months. *JAMA Psychiatry*. 70(11): 1181-9. doi: 10.1001/jamapsychiatry.2013.2430.
- Henderson, S., Jorm, A. F., Scott, L. R., Mackinnon, A. J., Christensen, H., & Korten, A. E. (1995). Insomnia in the elderly: Its prevalence and correlates in the general population. *The Medical Journal of Australia*, 162, 22-24.
- Hingson, R. W., Zha, W., & Weitzman, E. R. (2009). Magnitude of and trends in alcohol-related mortality and morbidity among U.S. college students ages 18-24, 1998-2005. *J.Stud.Alcohol Drugs Suppl*, (16), 12-20. Retrieved from PM:19538908
- Hirschfeld, R.M.A, Williams, J.B., Spitzer, R.L., Calabrese, J.R., Flynn, L., Keck, P.E. et al. (2000). Development and validation of a screening instrument for bipolar spectrum disorder: The Mood Disorder Questionnaire. *Am J Psychiatry*, 157(11), 1873-1875.
- Hirschfeld, R.M.A. (2002). The mood disorder questionnaire: A simple, patient-rated screening instrument for bi-polar disorder. *J Clin Psychiatry Primary Care Companion*, 4, 9-11.
- Hirschfeld, R.M.A. (2005). Screening for bipolar disorder in patients treated for depression in a family medicine clinic. *JABFP*, 18, 233-239.

- Hopp, H., Troy, A.S., & Mauss, I.B. (2011). The unconscious pursuit of emotion regulation: Implications for psychological health. *Cogn Emot.* 25(3): 532-45. doi: 10.1080/02699931.2010.532606
- Horne, J. A., & Ostberg, O. (1976). A self-assessment questionnaire to determine morningness- eveningness in human circadian rhythms. *Int J Chronobiol*, 4(2), 97-110. Retrieved from PM:1027738
- Howells, N.L. & Orcutt, H.K. (2014). Diary study of sexual risk taking, alcohol use, and strategies for reducing negative affect in female college students. *J Stud Alcohol Drugs.* 75(3): 399-403.
- Hoyle, R.H., Stephenson, M.T., Palmgreen, P., Lorch, E.P., & Donohew, R.L. (2002). Reliability and validity of a brief measure of sensation seeking. *Personality and Individual Differences*, 32, 401- 414.
- Hsu, C. Y., Gau, S. S., Shang, C. Y., Chiu, Y. N., & Lee, M. B. (2012). Associations between chronotypes, psychopathology, and personality among incoming college students. *Chronobiol.Int.*, 29(4), 491-501. doi:10.3109/07420528.2012.668995 [doi]. Retrieved from PM:22497432
- Ishihara, K., Miyasita, A., Inugami, M., Fukuda, K., Yamazaki, K., & Miyata, Y. (1985). Differences in the time or frequency of meals, alcohol and caffeine ingestion, and smoking found between 'morning' and 'evening' types. *Psychol.Rep.*, 57(2), 391-396. doi:10.2466/pr0.1985.57.2.391 [doi]. Retrieved from PM:4059451
- Jennings, J. R., Kamarck, T., Stewart, C., Eddy, M., & Johnson, P. (1992). Alternate cardiovascular baseline assessment techniques: vanilla or resting baseline. *Psychophysiology*, 29(6), 742-750. Retrieved from PM:1461961

- Jeong Jeong, H., Moon, E., Min Park, J., Dae Lee, Y., Choi, Y., & In Chung, Y. (2015). The relationship between chronotype and mood fluctuation in the general population. *Psychiatry Res*, 229(3), 867- 871.
- John, O.P., Donahu, E.M., & Kentle, R.L. (1991). The Big Five Inventory-- Versions 4a and 54. Berkeley, CA: University of California, Berkely, Institute of Personality and Social Research.
- Kabrita, C. S., Hajjar-Muca, T. A., & Duffy, J. F. (2014). Predictors of poor sleep quality among Lebanese university students: association between evening typology, lifestyle behaviors, and sleep habits. *Nat.Sci.Sleep*, 6, 11-18. doi:10.2147/NSS.S55538 [doi];nss-6-011 [pii]. Retrieved from PM:24470782
- Kahle, S., Miller, J.G., Lopez, M., & Hastings, P.D. (2015). Sympathetic recovery from anger is associated with emotion regulation. *Journal of Experimental Child Psychology*, 142: 359-71. DOI: [10.1016/j.jecp.2015.10.004](https://doi.org/10.1016/j.jecp.2015.10.004)
- Kanerva, N., Kronholm, E., Partonen, T., Ovaskainen, M. L., Kaartinen, N. E., Konttinen, H. et al. (2012). Tendency toward eveningness is associated with unhealthy dietary habits. *Chronobiol.Int.*, 29(7), 920-927. doi:10.3109/07420528.2012.699128 [doi]. Retrieved from PM:22823875
- Keller, M. B., Hanks, D. L., & Klein, D. N. (1996). Summary of the DSM-IV mood disorders field trial and issue overview. *Psychiatric Clinics of North America*, 19(1), 1-28. Retrieved from PM:8677213
- Khantzian, E.J. (1997). The self-medication hypothesis of substance use disorders: A reconsideration and recent applications. *Harv Rev Psychiatry*. 4(5): 231-44. DOI: 10.3109/10673229709030550
- Khosravani, V., Sharifi Bastan, F., Ghorbani, F., & Kamali, Z. (2017). Difficulties in emotion

- regulation mediate negative and positive affects and craving in alcoholic patients.
Addict Behav. 71: 75-81. doi: 10.1016/j.addbeh.2017.02.029.
- Kim, S.H. & Hamann, S. (2007). Neural correlates of positive and negative emotion regulation. *J Cogn Neurosci*. 19(5): 776-98. DOI: 10.1162/jocn.2007.19.5.776
- Klanecky, A. K., Woolman, E. O., & Becker, M. M. (2015). Child abuse exposure, emotion regulation, and drinking refusal self-efficacy: an analysis of problem drinking in college students. *American Journal of Drug and Alcohol Abuse*, 41(2), 188-196.
doi:10.3109/00952990.2014.998365 [doi]. Retrieved from PM:25700007
- Korczak, A. L., Martynhak, B. J., Pedrazzoli, M., Brito, A. F., & Louzada, F. M. (2008). Influence of chronotype and social zeitgebers on sleep/wake patterns.
Braz.J.Med.Biol.Res., 41(10), 914-919. Retrieved from PM:18982197
- Lane, R. D., McRae, K., Reiman, E. M., Chen, K., Ahern, G. L., & Thayer, J. F. (2009). Neural correlates of heart rate variability during emotion. *Neuroimage.*, 44(1), 213-222.
doi:S1053-8119(08)00892- 6 [pii];10.1016/j.neuroimage.2008.07.056 [doi]. Retrieved from PM:18778779
- Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: affective, facial, visceral, and behavioral reactions. *Psychophysiology*, 30(3), 261-273.
Retrieved from PM:8497555
- Lara, T., Madrid, J.A., & Correa, A. (2014). The vigilance decrement in executive function is attenuated when individual chronotypes perform at their optimal time of day. *PLoS One*. 9(2): e88820. doi: 10.1371/journal.pone.0088820.
- Lau, E.Y., Wong, M.L., Ng, E.C., Hui, C.C., Cheung, S.F., & Mok, D.S. (2013). "Social jetlag" in morning-type college students living on campus: Implications for physical and psychological well-being. *Chronobiol Int*. 30(7): 910-8. doi:

10.3109/07420528.2013.789895

- LeBlanc, N. J., Unger, L. D., & McNally, R. J. (2016). Emotional and physiological reactivity in Complicated Grief. *Journal of Affective Disorders*, 194, 98-104. doi:S0165-0327(15)30921-6 [pii];10.1016/j.jad.2016.01.024 [doi]. Retrieved from PM:26803781
- Lejuez, C. W., Magidson, J. F., Mitchell, S. H., Sinha, R., Stevens, M. C., & de, W. H. (2010). Behavioral and biological indicators of impulsivity in the development of alcohol use, problems, and disorders. *Alcohol Clin.Exp.Res.*, 34(8), 1334-1345. doi:ACER1217 [pii];10.1111/j.1530- 0277.2010.01217.x [doi]. Retrieved from PM:20491733
- Lerner, J. S., & Keltner, D. (2001). Fear, anger, and risk. *Journal of Personality and Social Psychology*, 81(1), 146-159. Retrieved from PM:11474720
- Lopez-Vergara, H.I., Spillane, N.S., Merrill, J.E., & Jackson, K.M. (2016). Developmental trends in alcohol use initiation and escalation from early- to middle-adolescence: Prediction by urgency and trait affect. *Psychol Addict Behav.* 30(5): 578-87. doi: 10.1037/adb0000173
- Lozano, D.L., Norman, G., Knox, D., Wood, B.L., Miller, B.D., Emery, C.F., & Bernston, G.G. (2007). Where to B in dZ/dt . *Psychophysiology*. 44(1): 113-9. DOI:[10.1111/j.1469-8986.2006.00468.x](https://doi.org/10.1111/j.1469-8986.2006.00468.x)
- MacKinnon, D.P., Lockwood, C.M., & Williams, J. (2004). Confidence limits for the indirect effect: Distribution of the product and resampling methods. *Multivariate Behav Res.* 39(1): 99. doi: [10.1207/s15327906mbr3901_4](https://doi.org/10.1207/s15327906mbr3901_4)
- Malik, M. & Camm, A.J. (1993). Components of heart rate variability--what they really mean and what we really measure. *The American Journal of Cardiology*, 72(11), 821-822.
- Mallinckrodt, B., Abraham, W.T., Wei, M., & Russell, D.W. (2006). Advances in testing the

- statistical significance of mediation effects. *Journal of Counseling Psychology*, 53(3): 372-78. DOI: 10.1037/0022-0167.53.3.372
- Maquet, P., Peters, J.-M., Delfiore, G., Aerts, J., Degueldre, C., Fuchs, S. et al. (1995). Regional cerebral haemodynamics during slow sleep and paradoxical sleep. Preliminary results of a positron emission tomography (PET) study. *Sleep Research*, 24A, 89.
- Martin, J. S., Gaudreault, M. M., Perron, M., & Laberge, L. (2016). Chronotype, Light Exposure, Sleep, and Daytime Functioning in High School Students Attending Morning or Afternoon School Shifts: An Actigraphic Study. *J.Biol.Rhythms*. doi:0748730415625510 [pii];10.1177/0748730415625510 [doi]. Retrieved from PM:26825618
- May, C.P. & Hasher, L. (1998). Synchrony effects in inhibitory control over thought and action. *J Exp Psychol Hum Percept Perform*. 24(2): 363-79.
- McCraty, R., Atkinson, M., Tiller, W.A., Rein, G., & Watkins, A.D. (1995). The effects of emotions on short-term power spectrum analysis of heart rate variability. *Am J Cardiol*. 76(14): 1089-93.
- McHugh, R.K., Kaufman, J.S., Frost, K.H., Fitzmaurice, G.M., & Weiss, R.D. (2013). Positive affect and stress reactivity in alcohol-dependent outpatients. *J Studies on Alcohol and Drugs*. 74(1): 152-7.
- McLaughlin, K.A., Sheridan, M.A., Alves, S., & Mendes, W.B. (2014). Child maltreatment and autonomic nervous system reactivity: Identifying dysregulated stress reactivity patterns using the biopsychosocial model of challenge and threat. *Psychosom Med*. 76(7): 538-46. doi: 10.1097/PSY.0000000000000098
- McMakin, D. L., Dahl, R. E., Buysse, D. J., Cousins, J. C., Forbes, E. E., Silk, J. S. et al.

- (2016). The impact of experimental sleep restriction on affective functioning in social and nonsocial contexts among adolescents. *Journal of Child Psychology and Psychiatry*, 57(9), 1027-1037. doi:10.1111/jcpp.12568 [doi]. Retrieved from PM:27302148
- McRae, K., Ochsner, K. N., Mauss, I. B., Gabrieli, J. D., & Gross, J. J. (2008). Gender differences in emotion regulation: An fMRI study of cognitive reappraisal. *Group Processes & Intergroup Relations*, 11 (2), 143-162.
- Meiselman, H. (Ed.). (2016). Emotion Measurement. Sawston, United Kingdom: Woodhead Publishing
- Merikanto, I., Kronholm, E., Peltonen, M., Laatikainen, T., Lahti, T., & Partonen, T. (2012). Relation of chronotype to sleep complaints in the general Finnish population. *Chronobiol.Int.*, 29(3), 311- 317. doi:10.3109/07420528.2012.655870 [doi]. Retrieved from PM:22390244
- Mezick, E.J., Matthews, K.A., Hall, M.H., Jennings, J.R., & Kamarck, T.W. (2014). Sleep duration and cardiovascular response to stress in undergraduate men. *Psychophysiology*. 51(1). doi: 10.1111/psyp.12144
- Miklowitz, D. J., Otto, M. W., Frank, E., Reilly-Harrington, N. A., Kogan, J. N., Sachs, G. S. et al. (2007). Intensive psychosocial intervention enhances functioning in patients with bipolar depression: results from a 9-month randomized controlled trial. *American Journal of Psychiatry*, 164(9), 1340-1347. Retrieved from PM:17728418
- Miller, D. K., Malmstrom, T. K., Joshi, S. A. E. M., Morley, J. E., & Wolinsky, F. D. (2004). Clinically relevant levels of depressive symptoms in community-swelling middle-aged African Americans. *Journal of the American Geriatrics Society*, 52, 741-748.
- Miller, M.A., Rothernberger, S.D., Hasler, B.P., Donofry, S.D., Wong, P.M., Manuck, S.B., Kamark, T.W., & Roecklein, K.A. (2015). Chronotype predicts positive affect rhythms

- measured by ecological momentary assessment. *Chronobiol Int.* 32(3): 376-84. doi: 10.3109/07420528.2014.983602
- Miyamoto, Y., & Ma, X. (2011). Dampening or savoring positive emotions: a dialectical cultural script guides emotion regulation. *Emotion.*, 11(6), 1346-1357. doi:2011-20236-001 [pii];10.1037/a0025135 [doi]. Retrieved from PM:21910543
- Muller, D., Judd, C.M., & Yzerbyt, V.Y. (2005). When moderation is mediated and mediation is moderated. *J Pers Soc Psychol*, 89(6): 852-63. DOI: 10.1037/0022-3514.89.6.852
- Musser, E.D., Backs, R.W., Schmitt, C.F., Ablow, J.C., Measelle, J.R., & Nigg, J.T. (2011). Emotion regulation via the autonomic nervous system in children with attention-deficit/hyperactivity disorder (ADHD). *J Abnorm Child Psychol.* 39(6): 841-52. doi: 10.1007/s10802-011-9499-1.
- Nakade, M., Takeuchi, H., Kurotani, M., & Harada, T. (2009). Effects of meal habits and alcohol/cigarette consumption on morningness-eveningness preference and sleep habits by Japanese female students aged 18-29. *J.Physiol Anthropol.*, 28(2), 83-90. doi:JST.JSTAGE/jpa2/28.83 [pii]. Retrieved from PM:19346668
- Nakazaki, C., Noda, A., Koike, Y., Yamada, S., Murohara, T., & Ozaki, N. (2012). Association of insomnia and short sleep duration with atherosclerosis risk in the elderly. *Am.J.Hypertens.*, 25(11), 1149-1155. doi:ajh2012107 [pii];10.1038/ajh.2012.107 [doi]. Retrieved from PM:22854638
- Natale, V., & Alzani, A. (2000). Additional validity evidence for the composite scale of morningness. *Pers Indiv Differ.* 30: 293-301.
- Nebel, L. E., Howell, R. H., Krantz, D. S., Falconer, J. J., Gottdiener, J. S., & Gabbay, F. H. (1996). The circadian variation of cardiovascular stress levels and reactivity:

- relationship to individual differences in morningness/eveningness. *Psychophysiology*, 33(3), 273-281. Retrieved from PM:8936396
- Negriff, S., Dorn, L. D., Pabst, S. R., & Susman, E. J. (2011). Morningness/eveningness, pubertal timing, and substance use in adolescent girls. *Psychiatry Research*, 185(3), 408-413. doi:S0165- 1781(10)00380-X [pii];10.1016/j.psychres.2010.07.006 [doi]. Retrieved from PM:20674040
- Nolen-Hoeksema, S. (2012). Emotion regulation and psychopathology: the role of gender. *Annu.Rev.Clin.Psychol.*, 8, 161-187. doi:10.1146/annurev-clinpsy-032511-143109 [doi]. Retrieved from PM:22035243
- Nolen-Hoeksema, S., & Hilt, L. (2006). Possible contributors to the gender differences in alcohol use and problems. *Journal of General Psychology*, 133(4), 357-374. doi:10.3200/GENP.133.4.357-374 [doi]. Retrieved from PM:17128956
- Nowakowska-Domagala, K., Mokros, L., Jablkowska-Gorecka, K., Grzelinska, J., & Pietras, T. (2016). The relationship between chronotype and personality among patients with alcohol dependence syndrome: Pilot study. *Chronobiol Int.* 33(10): 1351-8. DOI:[10.1080/07420528.2016.1213738](https://doi.org/10.1080/07420528.2016.1213738)
- Otoni, G. L., Antonioli, E., & Lara, D. R. (2012). Circadian preference is associated with emotional and affective temperaments. *Chronobiol.Int.*, 29(6), 786-793. doi:10.3109/07420528.2012.679329 [doi]. Retrieved from PM:22734579
- Owens, J.A., Dearth-Wesley, T., Lewin, D., Gioia, G., & Whitaker, R.C. (2016). Self-regulation and sleep duration, sleepiness, and chronotype in adolescents. *Pediatrics*, 138(6). doi: 10.1542/peds. 2016- 1406. Retrieved from PM:27940688
- Pabst, S. R., Negriff, S., Dorn, L. D., Susman, E. J., & Huang, B. (2009). Depression and anxiety in adolescent females: the impact of sleep preference and body mass index.

- J.Adolesc.Health*, 44(6), 554-560. doi:S1054-139X(08)00675-7
[pii];10.1016/j.jadohealth.2008.11.012 [doi]. Retrieved from PM:19465319
- Palmer, C. A., & Alfano, C. A. (2016). Sleep and emotion regulation: An organizing, integrative review.*Sleep Medicine Reviews*. doi:S1087-0792(16)00004-6
[pii];10.1016/j.smr.2015.12.006 [doi]. Retrieved from PM:26899742
- Patrick, M.E., Yeomans-Maldonado, G., & Griffin, J. (2016). Daily reports of positive and negative affect and alcohol and marijuana use among college student and nonstudent young adults. *Subst Use Misuse*, 51(1): 54-61. doi: 10.3109/10826084.2015.1074694.
- Patterson, F., Malone, S. K., Lozano, A., Grandner, M. A., & Hanlon, A. L. (2016). Smoking, Screen- Based Sedentary Behavior, and Diet Associated with Habitual Sleep Duration and Chronotype: Data from the UK Biobank. *Ann.Behav.Med.*, 50(5), 715-726.
doi:10.1007/s12160-016-9797-5 [doi];10.1007/s12160-016-9797-5 [pii]. Retrieved from PM:27056396
- Peacock, A., Cash, C., Bruno, R., & Ferguson, S.G. (2015). Day-by-day variation in affect, arousal and alcohol consumption in young adults. *Drug Alcohol Rev.* 34(6): 588-94.
doi: 10.1111/dar.12238
- Pedersen, W.S. & Larson, C.L. (2016). State anxiety carried over from prior threat increases late positive potential amplitude during an instructed emotion regulation task. *Emotion*. 16(5): 19-29. doi: 10.1037/emo0000154.
- Peira, N., Fredrikson, M., & Pourtois, G. (2014). Controlling the emotional heart: Heart rate biofeedback improves cardiac control during emotional reactions. *Int J Psychophysiol.* 91(3): 225-31. doi: 10.1016/j.ijpsycho.2013.12.008.
- Pena-Sarrionandia, A., Mikolajczak, M., & Gross, J. J. (2015). Integrating emotion regulation and emotional intelligence traditions: a meta-analysis. *Front Psychol.*,

- 6, 160. doi:10.3389/fpsyg.2015.00160 [doi]. Retrieved from PM:25759676
- Pinna, G. D., Maestri, R., Torunski, A., Danilowicz-Szymanowicz, L., Szwoch, M., La Rovere, M. T. et al. (2007). Heart rate variability measures: a fresh look at reliability. *Clin.Sci.(Lond)*, 113(3), 131- 140. doi:CS20070055 [pii];10.1042/CS20070055 [doi]. Retrieved from PM:17381425
- Porges, S. W. (1995). Cardiac vagal tone: a physiological index of stress. *Neurosci.Biobehav.Rev.*, 19(2), 225-233. doi:014976349400066A [pii]. Retrieved from PM:7630578
- Prat, G., & Adan, A. (2011). Influence of circadian typology on drug consumption, hazardous alcohol use, and hangover symptoms. *Chronobiol.Int.*, 28(3), 248-257. doi:10.3109/07420528.2011.553018 [doi]. Retrieved from PM:21452920
- Prather, A. A., Bogdan, R., & Hariri, A. R. (2013). Impact of sleep quality on amygdala reactivity, negative affect, and perceived stress. *Psychosomatic Medicine*, 75(4), 350-358. doi:PSY.0b013e31828ef15b [pii];10.1097/PSY.0b013e31828ef15b [doi]. Retrieved from PM:23592753
- Preacher, K. J., Rucker, D. D., & Hayes, A. F. (2007). Addressing Moderated Mediation Hypotheses: Theory, Methods, and Prescriptions. *Multivariate.Behav.Res.*, 42(1), 185-227. doi:10.1080/00273170701341316 [doi]. Retrieved from PM:26821081
- Prins, A., Ouimette, P., Kimerling, R., Cameron, R. P., Hugelshofer, D. S., Shaw-Hegwer, J., Thrailkill, A., Gusman, F.D., Sheikh, J. I. (2003). The Primary Care PTSD Screen (PC-PTSD): Development and operating characteristics (PDF). *Primary Care Psychiatry*, 9, 9-14. doi: 10.1185/135525703125002360 PILOTS ID: 26676
- Quartana, P. J., & Burns, J. W. (2010). Emotion suppression affects cardiovascular responses to initial and subsequent laboratory stressors. *Br.J.Health Psychol.*, 15(Pt 3), 511-528.

- doi:bjhp656 [pii];10.1348/135910709X474613 [doi]. Retrieved from PM:19840496
- Radomski, S. A., & Read, J. P. (2016). Mechanistic Role of Emotion Regulation in the PTSD and Alcohol Association. *Traumatology.(Tallahass.Fla.)*, 22(2), 113-121. doi:10.1037/trm0000068 [doi]. Retrieved from PM:27398074
- Randler, C. (2011). Age and gender differences in morningness-eveningness during adolescence. *J.Genet.Psychol.*, 172(3), 302-308. doi:10.1080/00221325.2010.535225 [doi]. Retrieved from PM:21902008
- Rauer, A. J., Kelly, R. J., Buckhalt, J. A., & El-Sheikh, M. (2010). Sleeping with one eye open: marital abuse as an antecedent of poor sleep. *J.Fam.Psychol.*, 24(6), 667-677. doi:2010-25811-001 [pii];10.1037/a0021354 [doi]. Retrieved from PM:21171765
- Ray, R.D., McRae, K., Ochsner, K.N., & Gross, J.J. (2010). Cognitive reappraisal of negative affect: Converging evidence from EMG and self-report. *Emotion*, 10(4), 587-592.
- Reidy, B. L., Hamann, S., Inman, C., Johnson, K. C., & Brennan, P. A. (2016). Decreased sleep duration is associated with increased fMRI responses to emotional faces in children. *Neuropsychologia*, 84, 54-62. doi:S0028-3932(16)30027-6 [pii];10.1016/j.neuropsychologia.2016.01.028 [doi]. Retrieved from PM:26821063
- Reyes del Paso, G. A., Langewitz, W., Mulder, L. J., van, R. A., & Duschek, S. (2013). The utility of low frequency heart rate variability as an index of sympathetic cardiac tone: a review with emphasis on a reanalysis of previous studies. *Psychophysiology*, 50(5), 477-487. doi:10.1111/psyp.12027 [doi]. Retrieved from PM:23445494
- Rique, G. L., Fernandes Filho, G. M., Ferreira, A. D., & de Sousa-Munoz, R. L. (2014). Relationship between chronotype and quality of sleep in medical students at the Federal

- University of Paraiba, Brazil. *Sleep Sci.*, 7(2), 96-102. doi:10.1016/j.slsci.2014.09.004 [doi];S1984-0063(14)00031-5 [pii]. Retrieved from PM:26483910
- Robinson, J.L. & Demaree, H.A. (2009). Experiencing and regulating sadness: Physiological and cognitive effects. *Brain Cogn*, 70(1): 13-20. doi: 10.1016/j.bandc.2008.06.007
- Robinson, D., Gelaye, B., Tadesse, M. G., Williams, M. A., Lemma, S., & Berhane, Y. (2013). Daytime Sleepiness, Circadian Preference, Caffeine Consumption and Khat Use among College Students in Ethiopia. *J.Sleep Disord.Treat.Care*, 3(1). doi:10.4172/2325-9639.1000130 [doi]. Retrieved from PM:24818170
- Roenneberg, T., Kuehnle, T., Juda, M., Kantermann, T., Allebrandt, K., Gordjin, M., & Merrow, M. (2007). Epidemiology of the human circadian clock. *Sleep Med Rev.*, 11(6): 429-38. DOI:[10.1016/j.smrv.2007.07.005](https://doi.org/10.1016/j.smrv.2007.07.005)
- Roenneberg, T., Kuehnle, T., Pramstaller, P. P., Ricken, J., Havel, M., Guth, A. et al. (2004). A marker for the end of adolescence. *Curr.Biol.*, 14(24), R1038-R1039. doi:S0960982204009285 [pii];10.1016/j.cub.2004.11.039 [doi]. Retrieved from PM:15620633
- Roeser, K., Oberqfell, F., Meule, A., Vogele, C., Schlarb, A.A., & Kubler, A. (2012). Of larks and hearts- morningness/eveningness, heart rate variability and cardiovascular stress response at different times of day. *Physiol Behav*, 106(2), 151-157.
- Rossa, K. R., Smith, S. S., Allan, A. C., & Sullivan, K. A. (2014). The effects of sleep restriction on executive inhibitory control and affect in young adults. *J.Adolesc.Health*, 55(2), 287-292. doi:S1054-139X(14)00006-8 [pii];10.1016/j.jadohealth.2013.12.034 [doi]. Retrieved from PM:24602612
- Rupp, T. L., Acebo, C., & Carskadon, M. A. (2007). Evening alcohol suppresses salivary

- melatonin in young adults. *Chronobiol.Int.*, 24(3), 463-470. doi:779829454 [pii];10.1080/07420520701420675 [doi]. Retrieved from PM:17612945
- Rush, A.J., Trivedi, M.H., Ibrahim, H.M., Carmody, T.J., Arnow, B., Klein, D.N. (2003). The 16-item Quick Inventory of Depressive Symptomatology (QIDS), clinician rating (QIDS-C) , and self- report (QIDS-SR): A psychometric evaluation in patients with chronic major depression. *Biol Psychiatry*, 54(5), 573-583.
- Schachinger, H., Weinbacher, M., Kiss, A., Ritz, R., & Langewitz, W. (2001). Cardiovascular indices of peripheral and central sympathetic activation. *Psychosom Med.* 63(5): 788-96.
- Schlarb, A. A., Sopp, R., Ambiel, D., & Grunwald, J. (2014). Chronotype-related differences in childhood and adolescent aggression and antisocial behavior--a review of the literature. *Chronobiol.Int.*, 31(1), 1-16. doi:10.3109/07420528.2013.829846 [doi]. Retrieved from PM:24147657
- Schneider, W., Eschman, A., & Zuccolotto, A. (2002). E-Prime user's guide. Psychology software tools, Inc. Learning Research and Development Center, University of Pittsburgh.
- Selzer, M.L. (1971). The Michigan alcoholism screening test: The quest for a new diagnostic instrument. *Am J Psychiatry*, 127(12): 1653-8.
- Sheppes, G., & Levin, Z. (2013). Emotion regulation choice: selecting between cognitive regulation strategies to control emotion. *Front Hum.Neurosci.*, 7, 179. doi:10.3389/fnhum.2013.00179 [doi]. Retrieved from PM:23658540
- Sheppes, G., & Meiran, N. (2007). Better late than never? On the dynamics of online regulation of sadness using distraction and cognitive reappraisal. *Pers.Soc.Psychol.Bull.*, 33(11), 1518-1532. doi:0146167207305537

- [pii];10.1177/0146167207305537 [doi]. Retrieved from PM:17933748
- Sherwood, A., Allen, M.T., Obrist, P.A., & Langer, A.W. (1986). Evaluation of beta-adrenergic influences on cardiovascular and metabolic adjustments to physical and psychological stress. *Psychophysiology*, 23(1): 89-104.
- Shrout, P. E., & Bolger, N. (2002a). Mediation in experimental and nonexperimental studies: new procedures and recommendations. *Psychol.Methods*, 7(4), 422-445. Retrieved from PM:12530702
- Shrout, P. E., & Bolger, N. (2002b). Mediation in experimental and nonexperimental studies: new procedures and recommendations. *Psychological Methods*, 7(4), 422-445. Retrieved from PM:12530702
- Simons, J.S., Gaher, R.M., Oliver, M.N., Bush, J.A., & Palmer, M.A. (2005). An experience sampling study of associations between affect alcohol use and problems among college students. *J Stud Alcohol*. 66(4): 459-69.
- Smith, C.S., Reilly, C., & Midkiff, K. (1989). Evaluation of three circadian rhythm questionnaires with suggestions for an improved measure of morningness. *J Appl Psychol*. 74(5): 728-38.
- Smith, T. W., Cribbet, M. R., Nealey-Moore, J. B., Uchino, B. N., Williams, P. G., MacKenzie, J. et al. (2011). Matters of the variable heart: respiratory sinus arrhythmia response to marital interaction and associations with marital quality. *J.Pers.Soc.Psychol.*, 100(1), 103-119. doi:2010-21677-001 [pii];10.1037/a0021136 [doi]. Retrieved from PM:20954783
- Sobel, M. E. (1982). Asymptomatic confidence intervals for indirect effects in structural equation models. *Sociological Methodology*, 13, 290-312.
- Stasiewicz, P. R., Bradizza, C. M., Schlauch, R. C., Coffey, S. F., Gulliver, S. B., Gudleski, G.

- D. et al. (2013). Affect regulation training (ART) for alcohol use disorders: development of a novel intervention for negative affect drinkers. *Journal of Substance Abuse Treatment*, 45(5), 433-443. doi:S0740-5472(13)00116-5 [pii];10.1016/j.jsat.2013.05.012 [doi]. Retrieved from PM:23876455
- Steptoe, A., O'Donnell, K., Marmot, M., & Wardle, J. (2008). Positive affect, psychological well-being, and good sleep. *Journal of Psychosomatic Research*, 64(4), 409-415. Retrieved from PM:18374740
- Taillard, J., Philip, P., & Bioulac, B. (1999). Morningness/eveningness and the need for sleep. *Journal of Sleep Research*, 8(4), 291-295. Retrieved from PM:10646169
- Talkowski, M. E., Mansour, H., Chowdari, K. V., Wood, J., Butler, A., Varma, P. G. et al. (2006). Novel, replicated associations between dopamine D3 receptor gene polymorphisms and schizophrenia in two independent samples. *Biological Psychiatry*, 60(6), 570-577. Retrieved from PM:16893532
- Tavernier, R., Munroe, M., & Willoughby, T. (2015). Perceived morningness-eveningness predicts academic adjustment and substance use across university, but social jetlag is not to blame. *Chronobiol.Int.*, 32(9), 1233-1245. doi:10.3109/07420528.2015.1085062 [doi]. Retrieved from PM:26507124
- Taylor, B.J., Hasler, B.P., Roecklein, K.A., & Hall, M.H. (2017). Chronotype and risk-taking: A systematic review of the literature with an emphasis on adolescent risk-taking and sex differences. Manuscript submitted for publication.
- Tempesta, D., Couyoumdjian, A., Curcio, G., Moroni, F., Marzano, C., De, G. L. et al. (2010). Lack of sleep affects the evaluation of emotional stimuli. *Brain Res.Bull.*, 82(1-2), 104-108. Retrieved from PM:20117179
- Thayer, J. F., Ahs, F., Fredrikson, M., Sollers, J. J., III, & Wager, T. D. (2012). A meta-

- analysis of heart rate variability and neuroimaging studies: implications for heart rate variability as a marker of stress and health. *Neurosci.Biobehav.Rev.*, 36(2), 747-756. doi:S0149-7634(11)00207-7 [pii];10.1016/j.neubiorev.2011.11.009 [doi]. Retrieved from PM:22178086
- Tobaldini, E., Nobile, L., Strada, S., Casali, K.R., Braquhiroli, A., Montano, N. (2013). Heart rate variability in normal and pathological sleep. *Front Physiol.* 4: 294. DOI: 10.3389/fphys.2013.00294
- Tonetti, L., Adan, A., Caci, H., De, P., V, Fabbri, M., & Natale, V. (2010). Morningness-eveningness preference and sensation seeking. *Eur.Psychiatry*, 25(2), 111-115. doi:S0924-9338(09)00165-5 [pii];10.1016/j.eurpsy.2009.09.007 [doi]. Retrieved from PM:19926258
- Torsvall, L., & Akerstedt, T. (1980). A diurnal type scale. Construction, consistency and validation in shift work. *Scand J Work Environ Health.* 6(4): 283-90.
- Townshend, J.M. & Duka, T. (2002). Patterns of alcohol drinking in a population of young social drinkers: A comparison of questionnaire and diary measures. *Alcohol Alcohol.* 37(2): 187-92.
- Troy, A. S., Wilhelm, F. H., Shallcross, A. J., & Mauss, I. B. (2010). Seeing the silver lining: cognitive reappraisal ability moderates the relationship between stress and depressive symptoms. *Emotion.*, 10(6), 783-795. doi:2010-23140-001 [pii];10.1037/a0020262 [doi]. Retrieved from PM:21058843
- Tucker, A.M., Feurstein, R., Mende-Siedlecki, P., Ochsner, K.N., & Stern, Y. (2012). Double dissociation: Circadian off-peak times increase emotional reactivity; aging impairs emotion regulation via reappraisal. *Emotion.* 12(5): 869-74. doi: 10.1037/a0028207.

Tzischinsky, O., & Shochat, T. (2011). Eveningness, sleep patterns, daytime functioning, and quality of life in Israeli adolescents. *Chronobiol.Int.*, 28(4), 338-343.

doi:10.3109/07420528.2011.560698 [doi]. Retrieved from PM:21539425

Udo, T., Bates, M.E., Mun, E.Y., Vaschillo, E.G., Vaschillo, B., Lehrer, P., & Ray, S. (2009). Gender differences in acute alcohol effects on self-regulation of arousal in response to emotional and alcohol-related picture cues. *Psychol Addict Behav.*, 23(2), 196-204.

Urban, R., Magyarodi, T., & Rigo, A. (2011). Morningness-eveningness, chronotypes and health- impairing behaviors in adolescents. *Chronobiol.Int.*, 28(3), 238-247.

doi:10.3109/07420528.2010.549599 [doi]. Retrieved from PM:21452919

US Department of Health and Human Services. Substance Abuse and Mental Health Services Administration. Center for Behavioral Health Statistics and Quality. National Survey on Drug Use and Health, 2013. ICPSR35509-v3. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2015-11-23.

<http://doi.org/10.3886/ICPSR35509.v3>

Virtanen, I., Kalleinen, N., Urrila, A.S., Lappanen, C., & Polo-Kantola, P. (2015). Cardiac autonomic changes after 40 hours of total sleep deprivation in women. *Sleep Med.* 16(2): 250-7. DOI: 10.1016/j.sleep.2014.10.012

Verweij, I. M., Romeijn, N., Smit, D. J., Piantoni, G., Van Someren, E. J., & Van Der Werf, Y. D. (2014). Sleep deprivation leads to a loss of functional connectivity in frontal brain regions. *BMC.Neurosci.*, 15, 88. doi:1471-2202-15-88 [pii];10.1186/1471-2202-15-88 [doi]. Retrieved from PM:25038817

Vitale, J. A., Roveda, E., Montaruli, A., Galasso, L., Weydahl, A., Caumo, A. et al. (2015). Chronotype influences activity circadian rhythm and sleep: differences in sleep quality

- between weekdays and weekend. *Chronobiol.Int.*, 32(3), 405-415.
doi:10.3109/07420528.2014.986273 [doi]. Retrieved from PM:25469597
- Voinescu, B.I., & Szentagotai, A. (2014). Emotion regulation and maladaptive beliefs in relation to morningness/eveningness. Presented at the 22nd Congress of the European Sleep Research Society in Tallinn, Estonia.
- Volk, S., Dyroff, J., Georgi, K., & Pflug, B. (1994). Subjective sleepiness and physiological sleep tendency in healthy young morning and evening subjects. *Journal of Sleep Research*, 3(3), 138-143. doi:jsr003003138 [pii]. Retrieved from PM:10607118
- Volokhov, R. N., & Demaree, H. A. (2010). Spontaneous emotion regulation to positive and negative stimuli. *Brain and Cognition*, 73(1), 1-6. doi:S0278-2626(09)00208-5 [pii];10.1016/j.bandc.2009.10.015 [doi]. Retrieved from PM:20347515
- Vriend, J. L., Davidson, F. D., Corkum, P. V., Rusak, B., Chambers, C. T., & McLaughlin, E. N. (2013). Manipulating sleep duration alters emotional functioning and cognitive performance in children. *J.Pediatr.Psychol.*, 38(10), 1058-1069. doi:jst033 [pii];10.1093/jpepsy/jst033 [doi]. Retrieved from PM:23720415
- Walters, S.T., Vader, A.M., Harris, T.R., & Jouriles, E.N. (2009). Reactivity to alcohol assessment measures: An experimental test. *Addiction*. 104(8): 1305-10. doi:10.1111/j.1360-0443.2009.02632.x.
- Watson, N. F., Buchwald, D., & Harden, K. P. (2013). A Twin Study of Genetic Influences on Diurnal Preference and Risk for Alcohol Use Outcomes. *Journal of Clinical Sleep Medicine*, 9(12), 1333-1339. Retrieved from ISI:000328690000016
- Webb, T. L., Miles, E., & Sheeran, P. (2012). Dealing with feeling: a meta-analysis of the effectiveness of strategies derived from the process model of emotion regulation. *Psychological Bulletin*, 138(4), 775-808. doi:2012-12790-001 [pii];10.1037/a0027600

[doi]. Retrieved from PM:22582737

Wechsler, H., Lee, J.E., Kuo, M., Seibring, M., Nelson, T.F., & Lee, H. (2002). Trends in college binge drinking during a period of increased prevention efforts. Findings from 4 Harvard School of Public Health College Alcohol Study surveys: 1993-2001. *J Am Coll Health*, 50(5): 203-17. DOI: 10.1080/07448480209595713

Weiss, W., Gohlisch, C., Harsch-Gladisch, C., Tolle, M., Zidek, W., & van der Giet, M. (2012). Oscillometric estimation of central blood pressure: validation of the Mobil-O-Graph in comparison with the SphygmoCor device. *Blood Press Monit.*, 17(3), 128-131. doi:10.1097/MBP.0b013e328353ff63 [doi];00126097-201206000-00007 [pii]. Retrieved from PM:22561735

Whittier, A., Sanchez, S., Castaneda, B., Sanchez, E., Gelaye, B., Yanez, D. et al. (2014). Eveningness Chronotype, Daytime Sleepiness, Caffeine Consumption, and Use of Other Stimulants Among Peruvian University Students. *J.Caffeine.Res.*, 4(1), 21-27. doi:10.1089/jcr.2013.0029 [doi];10.1089/jcr.2013.0029 [pii]. Retrieved from PM:24868492

Whittle, S., Yucel, M., Yap, M. B., & Allen, N. B. (2011). Sex differences in the neural correlates of emotion: evidence from neuroimaging. *Biol.Psychol.*, 87(3), 319-333. doi:S0301-0511(11)00138- 4 [pii];10.1016/j.biopsycho.2011.05.003 [doi]. Retrieved from PM:21600956

Williams, D. P., Cash, C., Rankin, C., Bernardi, A., Koenig, J., & Thayer, J. F. (2015). Resting heart rate variability predicts self-reported difficulties in emotion regulation: a focus on different facets of emotion regulation. *Front Psychol.*, 6, 261. doi:10.3389/fpsyg.2015.00261 [doi]. Retrieved from PM:25806017

Willis, T.A., O'Connor, D.B., & Smith, L. (2005). The influence of morningness-eveningness

- on anxiety and cardiovascular response to stress. *Physiol Behav*, 85(2), 125-133.
- Wilson, T. D., & Gilbert, D. T. (2008). Explaining Away: A Model of Affective Adaptation. *Perspect. Psychol. Sci.*, 3(5), 370-386. doi:3/5/370 [pii];10.1111/j.1745-6924.2008.00085.x [doi]. Retrieved from PM:26158955
- Wong, C. F., Silva, K., Kecojevic, A., Schrage, S. M., Bloom, J. J., Iverson, E. et al. (2013). Coping and emotion regulation profiles as predictors of nonmedical prescription drug and illicit drug use among high-risk young adults. *Drug Alcohol Depend.*, 132(1-2), 165-171. doi:S0376-8716(13)00037-9 [pii];10.1016/j.drugalcdep.2013.01.024 [doi]. Retrieved from PM:23453258
- World Health Organization. (2001). *The Alcohol Use Disorders Identification Test: Guidelines for Use in Primary Care - Audit* (2nd ed.). Geneva: World Health Organization.
- Wu, L., Winkler, M.H., Wieser, M.J., Andreatta, M., Li, Y., & Pauli, P. (2015). Emotion regulation in heavy smokers: Experiential, expressive and physiological consequences of cognitive reappraisal. *Front Psychol.* 6: 1555. doi: 10.3389/fpsyg.2015.01555
- Zhao, X., Lynch, J.G., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and truths about mediation analysis. *Journal of Consumer Research*, 37(2): 197-206.
- Zhong, X., Hilton, H.J., Gates, G.J., Jelic, S., Stern, Y., Bartels, M.N., Demeersman, R.E., & Basner, R.C. (2005). Increased sympathetic and decreased parasympathetic cardiovascular modulation in normal humans with acute sleep deprivation. *J Appl Physiol.* 98(6): 2024-32. DOI: 10.1152/japplphysiol.00620.2004
- Zohar, D., Tzischinsky, O., Epstein, R., & Lavie, P. (2005). The effects of sleep loss on medical residents' emotional reactions to work events: a cognitive-energy model. *Sleep*, 28(1), 47-54. Retrieved from PM:15700720